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# Assessment of Campbell/Quinsam Chinook Salmon (*Oncorhynchus tshawytscha*)

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## ABSTRACT

The development and assessment of effective management strategies for the rebuilding of chinook salmon stocks to historical levels requires accurate estimates of escapement as well as estimates of the relative contribution of hatchery and natural production to that escapement. In 1984, various "key streams" were chosen including the Campbell/Quinsam River system. The key stream program was designed as a means of monitoring escapement parameters in specific spawning areas and initiated in response to objectives set out in the Canada-U.S. Pacific Salmon Treaty. The goal for these selected streams was to use the escapement and exploitation information from these stocks as an indicator of harvest and exploitation rates for neighbouring stocks. The Quinsam/Campbell was chosen to represent Upper Georgia Strait/Johnstone Strait chinook.

Interim escapement goals for British Columbia chinook stocks were established by the Chinook Technical Committee (Pacific Salmon Commission 1986). Goals for natural and enhanced stocks were double the 1979-82 base period or, for key streams, double the 1984 escapement. The interim escapement goal for the Quinsam/Campbell was set at 5,970. Since 1989, chinook returns to the Campbell/Quinsam system initially continued to decline but in recent years have rebounded. However, the escapement goal has only been reached once (1999), even with substantial enhancement efforts.

The Campbell River was historically one of the most important producers of chinook in the Strait of Georgia. Three over-riding key aspects were identified to have contributed to the decline of the Campbell River chinook stock. Hydroelectric development and associated construction of dams and water diversions are suggested to have significantly contributed to the decline of salmon stocks. Major changes in river discharge and flow regimes are known to have considerable detrimental effects to both the adult and juvenile life stages. Secondly, the estuary has been used extensively by industry and for urban development which has also been documented to have had a considerable impact on the rearing capacity for juveniles. And finally, high exploitation of this stock in previous years at non-sustainable levels has obviously been detrimental to the natural chinook stock in the Campbell River.

Reduction in exploitation by approximately 50% since the late 70's and up to 500% improvements in marine survival in recent years should contribute substantially to the rebuilding process. In 1999 there were double the number of natural spawners in the Campbell River compared to the previous 5 years.

## RÉSUMÉ

L'élaboration et l'évaluation de stratégies de gestion efficaces visant le rétablissement des stocks de saumon quinnat à leurs niveaux historiques requièrent des estimations précises de l'échappée ainsi que des estimations de la contribution relative de la production des écloseries et du milieu sauvage à celle-ci. Un programme lancé en 1984 en réponse à des objectifs établis dans le Traité sur le saumon du Pacifique signé par le Canada et les États-Unis a servi à identifier divers cours d'eau « clés », y compris le réseau des rivières Campbell et Quinsam, où des paramètres de l'échappée dans des frayères spécifiques ont été contrôlés. L'objectif était d'utiliser les renseignements sur l'échappée et l'exploitation de ces stocks comme un indicateur des taux de récolte et d'exploitation des stocks voisins. Le réseau Quinsam-Campbell a été choisi comme représentatif du quinnat du haut détroit de Georgia et du détroit de Johnstone.

Le Comité technique du saumon quinnat (Commission du saumon du Pacifique, 1986) a fixé les objectifs intérimaires d'échappée pour les stocks de quinnat de la Colombie-Britannique. Dans le cas des stocks naturels et mis en valeur, les objectifs étaient deux fois ceux pour la période de référence 1979-1982 et, dans le cas des cours d'eau clés, deux fois les niveaux de 1984. L'objectif intérimaire d'échappée pour le réseau Quinsam-Campbell a été fixé à 5 970 saumons. À partir de 1989, les remontes de quinnat dans ce réseau ont continué à baisser, mais elle ont repris dans les dernières années. L'objectif d'échappée n'a toutefois été atteint qu'une fois (1999), en dépit de grands efforts de mise en valeur.

La rivière Campbell était autrefois l'un des tributaires du détroit de Georgia les plus producteurs de quinnat. Trois aspects clés prépondérants qui ont contribué au déclin du stock de quinnat de ce cours d'eau. Ils sont d'avis que l'aménagement hydroélectrique et la construction conséquente de barrages et le détournement des eaux ont grandement contribué à l'appauvrissement des stocks de saumon car il a été établi que d'importants changements dans les régimes de débit et d'écoulement ont de graves incidences sur les adultes et les juvéniles. En deuxième lieu, le développement urbain et le grand nombre d'industries dans l'estuaire sont reconnus comme ayant un effet marqué sur la capacité de grossissement des juvéniles. Et en dernier lieu, la forte exploitation de ce stock à des niveaux non soutenables par les années passées a visiblement nuit au stock de quinnat sauvage de la Campbell.

La réduction du taux d'exploitation d'environ 50 % depuis la fin des années 70 et l'amélioration allant jusqu'à 500 % du taux de survie en mer au cours des dernières années devraient nettement contribuer au processus de rétablissement. Ainsi, en 1999, le nombre de reproducteurs sauvages dans la rivière Campbell étaient deux fois celui observé au cours des cinq années précédentes.

**Introduction**

The Campbell/Quinsam watershed has received considerable attention, has been studied extensively and has a very colorful history. The system has been extensively dammed and diverted for hydro-electric power, has historically been considered a unique system for its tyee fishery, has been enhanced through a large hatchery facility since 1978, and was selected as an indicator stock for Upper Georgia/Johnstone Strait chinook. This document represents the first comprehensive compilation and examination of the data collected to date.

Groupings of chinook salmon populations in British Columbia are distinguished by geographic location, run timing of the spawning migration, distribution of catch in the ocean, and age at maturity. Five major groups of Canadian-origin chinook salmon are recognized around the Strait of Georgia; including upper Fraser River spring and summer chinook, Harrison River white fall chinook, Mainland inlet summer chinook, far-north migrating fall chinook in the upper Strait, and the Lower Strait of Georgia fall chinook group. For the purposes of this report, we use the assessment to the Quinsam/Campbell system as a stock representing the Upper Strait of Georgia fall chinook group.

The development and assessment of effective management strategies for the rebuilding of chinook salmon stocks to historical levels requires accurate estimates of escapement as well as estimates of the relative contribution of hatchery and natural production to that escapement. In 1984, various "key streams" were chosen for study, including the Campbell/Quinsam River system, in order to represent the overall status of chinook bearing streams along the British Columbia coast. The key stream program was designed as a means of monitoring escapement parameters in specific spawning areas. These selected streams provide ongoing information to fisheries managers in response to artificial (hatchery) and natural production, and harvest management strategies. The key stream program began in 1984, in accordance with objectives set out in the Canada-US Salmon Treaty. Chinook stock assessment requires an accurate estimation of escapement, and the contribution from artificial and natural means to fisheries and escapement.

The major objectives of the key stream program are:

1) to accurately estimate chinook escapement on key streams;
2) to estimate harvest rates and contributions to fisheries and escapement based on coded-wire tagged/adipose clip returns; and
3) to estimate the contribution of hatchery and natural production to the escapement.

**Study Area**

Campbell River originates east of the Vancouver Island mountain ranges and flows in an easterly direction for 65 km into Discovery Passage immediately north of the City of Campbell River (Fig 1). The Quinsam River, a major tributary of the Campbell River, flows in a northerly direction through a series of small lakes for approximately 30 km, flowing into the Campbell River approximately 3.8 km upstream of the Campbell River estuary. The drainage area of the Campbell system is 1,460 $km^2$ and of the Quinsam system is 265 $km^2$. Fish passage in the Campbell River is blocked by natural falls and an hydroelectric dam 5.5 km upstream of the estuary. Approximately

27 km of the Quinsam River is accessible to natural spawning but most chinook spawning usually takes place in the lower 4 km of the river (Shardlow *et al.* 1986).

Five species of Pacific salmon are found within the Campbell/Quinsam system. In order of abundance, these are pink (*Oncoryhnchus gorbuscha*), chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and sockeye (*O. nerka*). There are also Steelhead trout (*O. mykiss*), and Cutthroat trout (*O. clarki*). Chinook salmon have been observed spawning in the Campbell River above the Quinsam River confluence and in the Quinsam River from the confluence with the Campbell to above the hatchery counting fence (Andrew *et al.* 1988). Some chinook are allowed to proceed through the counting fence to spawn in the higher reaches of the lower Quinsam.

Mature chinook begin entering the Campbell River in mid-August with the migration peaking in October. Spawning occurs over several weeks from the middle of October to mid-November. Chinook entering the Quinsam River are more dependant on rainfall and consequently enter and spawn a little later than in the Campbell River, through November into early December.

**Habitat and Environmental Factors**

*Commercial & Industrial Development*

The city of Campbell River and its associated industry surrounds the lower two kilometres of the river. Therefore, the estuary and this lower section is highly modified. Urban development includes several road crossings, housing, and the Campbell River road which runs adjacent to the river along the south bank (Andrew *et al.* 1988).

Commercial development (Fig. 2) in the estuary includes log booming, sawmills, shake mills, a seaplane base, and moorage facilities for pleasure boats (Andrew *et al.* 1988). The estuary has been utilized for industrial activities since the early twentieth century. Commercial development in the Campbell R. estuary includes log booming, sawmills, shake mills, a seaplane base at Tyee spit, and pleasure boat moorage. Man-made islands have been constructed in the estuary in an effort to improve fish habitat (Levings 1986).

The International Timber Company began shipping logs out of the area in 1904. In 1905, the company took charge of a water lot lease for log storage in the estuary. Forestry operations in the region continued to make log storage in the estuary a necessity. As recently as 1980 approximately 40 hectares of the estuary waters were used for log storage. A Redi-Mix gravel operation at Tyee Spit ran from 1964 to 1974 (Lauga and Associates, 1994).

The upper watersheds of both the Quinsam River and the Campbell River have been logged for decades. Numerous roads have been built to allow access to the timber. As well, the upper watershed of the Quinsam River has been and is currently being mined for coal. According to Alderdice and McLean (1982), zinc and copper levels are rising in the system. Mineral mining is conducted in the headwaters of the Campbell, and forestry harvesting in the vicinity of the large lakes in the watershed.

*Hydro-electric development*

Development of the hydroelectric potential of the Campbell River commenced after the Second World War. At the time, the British Columbia Power Commission anticipated that the development would provide the foundation for economic growth in North Vancouver Island. The project originally consisted of the construction of three major dams and three generating stations (1947). As construction of Strathcona Generating station (the third and most upstream) project in the development was nearing completion, the Commission realized that the economic growth would surpass the electrical energy that could be generated from the Campbell River watershed. As a result three adjacent watershed basins, the Salmon River/Grilse Creek, the Heber River/Hunter and Crest Creeks, and the Quinsam River were partially diverted to the Campbell River basin to increase the net drainage area of the overall watershed.

The Campbell River hydroelectric development is made up of three impoundments and a series of diversions. The lowest dam on the system, completed in 1953, is the John Hart Dam which impounds John Hart Lake. Above John Hart Lake, Campbell Lake is impounded by Ladore Dam, built in 1957. Strathcona Dam is the highest impoundment in the watershed. It impounds Upper Campbell Lake and Buttle Lake (Hirst, 1991). The diversions are the Heber River diversion and Crest Creek diversions to Upper Campbell Lake, and both the Salmon and Quinsam Rivers to Campbell Lake (Burt and Burns, 1995).

The flow in the Campbell River is controlled by the John Hart generating station, located 5.5 km upstream of the estuary (Marshall *et al.* 1977). Flow varies from 1.2 $m^3$/sec to 826.0 $m^3$/sec (Table 1). Minimum flows on the Campbell River are dictated by an informal agreement between DFO and BC Hydro (Hirst, 1991). The terms of this agreement include: 1) minimum flows of 34 $m^3s^{-1}$ (1200 cfs) below John Hart Dam; 2) preferred flows of 51 $m^3s^{-1}$ (1800 cfs); and 3) a ramping rate of 80 minutes for flow changes between 34 and 51 $m^3s^{-1}$ (Burt and Burns, 1995). These flow regimes were not always adhered to since excess water storage had to be discharged due to safety concerns with the dam. For example, in some years the discharge levels were substantially outside the preferred range (Fig. 2), as described in the B.C. Hydro agreement.

The effects of modified hydrology on salmonids has been studied for many systems (Burt and Mundie 1986) and an extensive study was conducted on the Campbell River (Hamilton and Buell, 1976). Investigations into the effect of flow regulation on Campbell River salmonids suggest that flow fluctuations have had four adverse effects: 1) disruption of spawning, 2) stranding of juveniles, 3) diminution of food items, and 4) scouring of spawning gravel. Under the present flow regime, small and intermediate sized gravel are scoured from the lower river by the frequent rapid fluctuations in discharge and occasional excessive discharges.

The John Hart Dam is also thought to have stopped the natural recruitment of spawning gravel to the lower reaches of the Campbell River (Burt and Burns, 1995; Hamilton and Buell, 1976). Prior to construction of the John Hart Dam the limit of chinook upstream migration in the mainstem of the Campbell R. was a natural obstruction known as Elk Falls, located in a canyon about 5 km from the river mouth. Construction of the dam and total diversion of flow in the canyon area reduced flows to a very low level sustained by seepage from the dam. As a result, the post-development upstream limit of anadromous fish distribution in the river is the canyon pool adjacent to the John Hart powerhouse. The diversion of nearly all of the river around Moose, Deer and Elk Falls and the Campbell River canyon bypassed what was probably a good gravel transport

and production area. Historically, a quantity of various sized gravels, produced in the upstream drainage areas, would have been transported through the canyon area during periods of high flow. Under present conditions, periodic spilling of flood waters through the canyon is insufficient to produce or recruit significant amounts of replacement gravels. Second, gravels produced by tributaries of the Upper Campbell River never reaches the lower river because it becomes trapped in the man-made impoundments of Upper and Lower Campbell Lakes and John Hart Lake.

The Quinsam River watershed drains an area of 209 sq. km (Blackmun et al. 1985). The Quinsam River is the major tributary of the Campbell River and their confluence is 3.5 km above the Campbell River estuary. Major tributaries to the Quinsam River are Cold Creek, Iron River and Flintoff Creek. The Quinsam watershed is bounded north and west by a mountainous divide that isolates it from the Campbell watershed. Flows in the Quinsam system have been regulated by the British Columbia Hydro and Power Authority (B.C.H.P.A.) since 1956. There is a storage dam on Upper Quinsam Lake and a diversion dam above Middle Quinsam Lake which diverts Quinsam water via Gooseneck Lake into the Campbell system. There were no established minimum flow requirements for the Quinsam system prior to 1963. The B.C.H.P.A. water license, revised in 1963, established flow requirements for the Quinsam River above Middle Quinsam Lake and immediately below lower Quinsam Lake. Even with flow regulation, flooding still occurs in the lower river and possibly in other areas of the watershed.

*Impacts*

The Campbell River has historically been an important chinook salmon spawning habitat. The impoundment of the system, since 1947, has effected natural river dynamics, with minimal opportunity for gravel, organics and food items to be added to the system. Before dam construction the Campbell River was 65km long draining a watershed of nearly 1500km$^2$. The high kinetic energy of the lower river restricts rearing areas for juveniles. Since the construction of John Hart dam natural gravel recruitment to the Campbell River has virtually ceased. Over the past 50 years, periodic high flow events have resulted in the remaining gravel bed being flushed downstream through the estuary, leaving the river armoured with large cobbles and boulders, material unsuitable for salmonid spawning. Burt and Burns (1995) estimated the lower Campbell River contained only 1972 m$^2$ of usable spawning gravel for chinook (Table 2; Fig 4) and was considered to have a shortfall of 15,000 to 20,000 m$^2$ of spawning gravel based on a target escapement of 4000 chinook spawners and a requirement of 7.5 to 10 m$^2$ per female. A comparison with the analysis of river substrate in 1973 (Fig. 5) indicate that already then there had been a loss of appropriate gravel for spawning and the problem has become worse since then.

Discharges below 70 m$^3$s$^{-1}$ have been found to reduce the available spawning habitat, expose redds, reduce rearing habitat as well as lower available protective production areas for most salmonids (Hamilton and Buell, 1976).

High discharges above 100 m$^3$s$^{-1}$ impact negatively on the benthos, flushing both the benthos and supportive detritus from the river, scour out the gravel and reduce available rearing habitat. Although short term increases may be tolerable, the cumulative effects of very high discharge rates must be considered detrimental. The salmonid under incubation is therefore, at risk (Burt and Burns, 1995; Hamilton and Buell, 1976; Hirst, 1991). Moderate fluctuations in discharge (increases of 50% or decreases of 30%) were shown to have major disruptive impact on the spawning behaviour of chinook. The effects of sharp decreases were more significant than the effects of

corresponding increases. On the basis of comparisons of values before and after river regulation (Gailbraith 1973), the conclusion was reached that reductions in average maxima and increases in average minima demonstrate improved spawning and rearing conditions during the regulated period. While occasional flooding or low discharge may have been deleterious in the historical sense, it was believed that it is far more important to consider environmental variability under average circumstances. Daily fluctuations of 3000 cfs have far more serious consequences than one or two very large but comparatively gradual natural discharge changes per year, each taking several days to complete, or low flows occurring occasionally during a few weeks in August.

The Campbell River Estuary is very important to the salmonid resources. Hamilton and Buell (1976) reported that the estuary serves as a nursery for many species of salmonids. Campbell River chinook are dependent on the estuary as primary rearing habitat (Anderson, 1998).

The extensive history of log storage and industrial development has impacted the carrying capacity of the estuary. Large deposits of bark, the mooring facilities, dredging, and the alteration of the shoreline have reduced the productive capacity of the estuary (Anderson, 1998).

The increased heavy metal load in the flows of the Campbell/Quinsam system may affect salmonid survival rates. Steelhead trout, chinook, and coho, are most susceptible. Between February 1980 and September 1981, levels of heavy metals in water samples (3 tests in 38) were recorded to have been toxic for chinook (Alderdice and McLean, 1982).

In 1995, the Campbell River Hydro/Fisheries Advisory Board was established to address the concerns that were raised following a fall season of intensive rainfall. The Campbell River Interim Flow Management Strategy (CRIFMS) was then released in 1997. This document provides the framework for change to the existing discharge protocol to a more natural hydrograph (Anon, 1997).

*Changes in spawner distribution and holding patterns*

Prior to construction of the B.C. Hydro dam, the natural outflow of the water from Campbell Lake into the river occurred through a canyon section (with impassable falls). The dam blocked the flow and reduced flow through the canyon to a trickle. Based on historical information, the section of the canyon below the falls to where it meets with the main river (approx. 3-4 km) was presumed to be a good spawning area. As a result of the reduction in flow through this canyon chinook have no longer accessed the area below the falls. This is somewhat corroborated by swim survey spawner distribution information (Fig. 6) that shows that the numbers of spawners holding in the lower canyon pools (Area 1; Appendix Table 2) has decreased substantially over time.

In addition, alterations to the lower river/estuary also have caused changes in the holding patterns of spawners as they returned to the Campbell R. Prior to 1982, when there was a large pool and holding area in the estuary (Fig. 3, section 2). Returning chinook entered this area in September and remained there until October and then moved into the upper river. Subsequent changes to the estuary changed the structure of the holding area and as a result chinook no longer hold in this area but rather move into the upper river in September. This is corroborated by a considerable change in broodstock capture techniques and timing. According to hatchery staff, prior to 1983, chinook broodstock were captured in this large holding area in October but are now captured in holding pools below the Quinsam River broodstock fence below the hatchery (M. Trenholme, Quinsam Hatchery, pers. comm).

*Mitigating Projects*

The habitat restoration projects that have taken place in this system are the result of community initiative and partnerships between all levels of government, local groups, industry and stakeholders (Appendix A). There are two strategies in place that have gained support from all interested parties and government. The Campbell River Estuary Management Plan and the Campbell River Interim Flow Management Strategy provide a comprehensive approach to improving salmonid production in the watershed (Anderson, 1998).

In 1992, the Vancouver Island Hydro/Fisheries Technical Committee began to address hydroelectric impacts on anadromous fish resources on Vancouver Island and as a result a study of the lower Campbell River, below the John Hart Generating Station, was commissioned (Burt and Burns, 1995). An assessment report of carrying capacity of juvenile chinook based on 1994 data with historical 1982-86 data comparison of the Campbell River Estuary was completed in 1997 (Korman *et al.* 1997).

A number of restoration projects on the lower Campbell River mainstem have been initiated to address the shortfalls identified in the Burt and Burns (1995) report. Among these are: the Elk Falls Spawning Channel (1992, 1995); the Elk Falls Twin Side Channel; the Second Island Spawning Channel (1985, 1995, 1996); the Campbell River Gravel Placement Project (1997, 1998); and Raven Channel (1998). Most of these projects deal specifically with the lack of spawning habitat available to salmonids. Approximately 11,500 $m^2$ of spawning habitat and 1500 $m^2$ of rearing habitat have been created to date (Anderson, 1998).

Estuarine rearing capacity has been identified as a limiting factor to increased salmon production (Anderson, 1998; CRIFMS, 1997). A series of projects have been implemented in recent years to try and improve over past activities in the intertidal zone. These projects include: the creation of four intertidal islands (1982); river beach and intertidal bench creation (1996 and 1997); an intertidal bench creation at the abandoned Marine Link landing (1997); bank stabilization (1998); and east bank intertidal benching (1998). The net estuarine habitat production from these projects include 5700 $m^2$ of intertidal sedge marsh bench and 7800 $m^2$ of intertidal beach (Anderson, 1998).

**Escapement Trends and Goals**

Prior to 1984, chinook escapement to the Campbell River was estimated based on visual surveys conducted by DFO Fishery Officers. Since then an intensive escapement enumeration program for both the Campbell and Quinsam systems has been completed each year by Quinsam hatchery staff. This includes a Petersen carcass mark-recapture that provides an escapement estimate for the Campbell and Quinsam rivers, total enumeration of returns to the Quinsam hatchery, an estimate of the spawners above the hatchery fence, and a biosamping program for age and sex composition and coded-wire tag mark rates for each component.

Overall escapement of chinook to the Campbell/Quinsam watershed (Fig. 7) ranged from 2500-6000 in the 40's, 50's and 60's, experienced a substantial decline in the late 70's, increased dramatically in the 80's primarily due to significant hatchery production, and then again declined to low levels similar to those experienced in the late 70's. Specifically, chinook escapement to the Campbell River has declined from 4,200 (ten year average; 1967-77) to 536 (ten year average;

1987-97) in recent years. At the same time the Quinsam River chinook escapement has increased from negligible returns to an average of 2,800 chinook spawners (ten year average; 1987-97 hatchery plus Quinsam R. escapement). In the past two years however, there has been considerable improvement in escapement and for the first time in many years the numbers of spawners in the Campbell River has increased.

Interim escapement goals for British Columbia chinook stocks were established by the Chinook Technical Committee (Pacific Salmon Commission 1986). The goals were intended as initial targets to guide joint management actions under the Pacific Salmon Treaty. Goals for natural and enhanced stocks were double the 1979-82 base period or, for key streams, double the 1984 escapement. The interim escapement goal for the Quinsam/Campbell system was set at 5,970, double the 1984 adjusted mark-recapture estimate.

**Enhancement History**

The Quinsam River Hatchery, a Fisheries and Oceans enhancement facility, built in 1972 (Andrew et. al., 1988) approximately 3.7 kilometers up from the confluence with the Campbell River, enhances salmon and anadromous trout from the Quinsam and neighbouring streams. In recent years, various remote net pen sites have been used to examine alternate rearing and release strategies. Since 1986, chinook escapements to the Campbell River have ranged from 219 (1993) to 4,057 (1986). Escapements to the Quinsam River have ranged from 2,267 (1993) to 11,982 (1990). Total escapements to the system have ranged from a low of 2,486 (1993) to a peak of 15,380 (1990) (Frith, 1992). Prior to the operation of Quinsam Hatchery, the escapement of chinook salmon to the Quinsam River was negligible (Fish Habitat Inventory and Information Program, 1991).

The Quinsam River hatchery consists of a diversion dam at "COLD C", three concrete adult holding ponds, 15 concrete rearing ponds, a fish diversion fence, a fishway, residences and hatchery buildings. Annual production of chinook juveniles has ranged from 162,516 (1975) to 4,402,686 (1992). The current chinook production target is 2.3 million smolts released to the river and 1.0 million released from saltwater netpens. The facility also produces 1.2 million coho smolts, 3.5 million pink fry, 25 thousand steelhead smolts, small numbers of cutthroat and coho fry for planting in local streams and above barriers.

Hatchery reared chinook juveniles are typically released from early to late May (Table 3). Morley *et al.* (1996) studied the effects of juvenile chinook size and time of release in relation to returns at maturity. Highest survival rates were recorded for juveniles (6-10 g) released in early May. May releases showed the strongest release size effects, with larger juveniles returning at higher rates. These data form the framework for the release strategy utilized by Quinsam hatchery.

Intensive mark sampling at the Quinsam hatchery and in the Quinsam and Campbell rivers from a deadpitch program conducted annually since 1984 has provided the recovery of coded-wire tag information (Table 4). Estimates of enhanced contribution using adipose clip/coded-wire tag data requires a number of assumptions including that all hatchery releases are represented by a mark and that sampling of the adult spawners is random. Enhanced contribution to escapement (Fig. 9) has increased significantly in the Campbell River. Straying of hatchery chinook originating from Quinsam hatchery has been ongoing (Burt and Burns, 1995). Annual escapement estimates for the wild chinook stock show a declining trend. The percentage of hatchery contribution to the

Campbell River chinook population is increasing. The straying of hatchery produced chinook spawners into the Campbell River may give the illusion that the Campbell River chinook stock is doing relatively well (Burt and Burns, 1995). The hatchery contribution to the Quinsam River and Quinsam hatchery chinook returns is high. This is expected since prior to the hatchery opening there was no run of consequence on the Quinsam River. In some years the hatchery contribution to the Quinsam hatchery returns has been calculated at 100%. But in recent years there has been an increase in naturally spawning fish has reduced the enhanced contribution.

An alternate method of estimating enhanced contribution was developed by using otolith microstructure to determine hatchery and river-reared origin (Zhang *et al.* 1994). Samples of adult spawners were collected for several years but only the 1996 data has been analyzed. The percentage of spawners recovered in the Campbell River that was determined to be hatchery-reared was 60%. This compares favourably with the estimate of 57% based on coded-wire tag data. Since 1996, all chinook production has been marked with a thermal otolith mark. Sampling of subsequent spawning populations will permit a more direct and definitive assessment of the contribution of enhanced production.

**Biological Characteristics**

Biological data for chinook have been collected from two sources; hatchery and spawning ground. Hatchery staff routinely biosample chinook collected for brood stock. As part of the carcass mark-recapture program, all chinook recovered on the spawning grounds are sampled for marks.

Approximately 90% of the returning chinook adults have been 4 and 5 year olds in most years (Table 5), although recently there is an increasing proportion of 3 year old males. Chinook returning to the Quinsam/Campbell system are relatively large fish. Weighted mean post-orbital hypural (POH) length of adult male spawners has ranged between 673 – 806 mm, while those of adult females has ranged from 765 – 851 mm (Appendix Table 1).

Both female and male chinook salmon from the Campbell system primarily mature as four and five year olds. Age distribution of the Campbell River spawners has shifted slightly towards a younger returning spawner (Table 6). This trend seems to be evident in both sexes (Andrew *et al.* 1988; Bocking, 1991; Bocking *et al.* 1990; Frith, 1992; Frith and Nelson, 1995; Frith *et al.* 1993; Nagtegaal and Graf, 1998).

Quinsam River chinook mean age distribution for 1986 to 1990 show spawners returning primarily as four (53.1%) and five year olds (29.9) for males while females returned primarily as five (57.9%) and four year olds (36.9%). The 1991 to 1996 mean age distributions for Quinsam River again shows a slight shift to younger spawners returning, with males primarily returning at age four (55.6%) and age three (24.4%). A 10% decline in age five male spawners was evident while age three male spawners increased almost 10%.

The Quinsam hatchery chinook spawner age distribution differed very little between the periods 1986-90 and 1991-96. In both periods, males were primarily age four (1986-90: 55.7%; 1991-96: 56.5%) and age three (1986-90: 25%; 1991-96: 24.3%) while females were primarily age five (1986-90: 43.7%; 1991-96: 49.2%) and age four (1986-90: 52.4%; 1991-96: 47.3%).

Other studies conducted into the release and timing of chinook juveniles revealed larger hatchery juveniles at the time of release returned with a younger age distribution (Bilton, 1984; Bilton *et al.* 1982).

Fecundity information was collected by the Quinsam hatchery during broodstock biosampling (expressed as total eggs divided by number of females). Average fecundity of Quinsam chinook broodstock is approximately 6,000. Using the available adjusted fecundity estimates compared to female mean postorbital-hypural (POH) length there was no observable trend, however, mean fecundity has declined (Fig. 10). It should be noted that sample sizes were small.

According to Nagtegaal and Graf (1998), size specific fecundity of Quinsam chinook varies from year to year. Using a large number of chinook populations, Healey and Heard (1984) determined that mean fecundity was positively related to age at maturity. However, in a single population, the slope of the fecundity age relationship was less than expected if fecundity increases were to offset the effects of natural mortality in older age classes.

**Juvenile Chinook Production**

Campbell and Quinsam River chinook juveniles are considered to be 'ocean type' that migrate to the estuary shortly after emerging. Healey (1991) indicated that this life strategy is common for chinook in coastal streams.

Downstream movement of naturally reared chinook fry occurs primarily in April to June. Prior to 1989, there was no significant information on the downstream migration of juvenile chinook. Burt and Burns (1995) report that trapping in Elk Falls Spawning Channel indicated that chinook fry migrate from early April to the end of June with their migration peaking in early May. Campbell River mainstem chinook fry migrate during the same period, with their migration peaking in mid April.

Hatchery releases of chinook begin in early May and usually are completed by mid to late May. Both hatchery reared and naturally reared chinook fry densities peak in the estuary in late May (Korman *et al.* 1997).

*Egg to fry Survival*

A measure of egg to fry survival for the Quinsam/Campbell system was determined from counts (adults and juveniles) for chinook that spawned above the Quinsam R. fence facility just above the hatchery. The calculation of egg to fry survival rates is dependent on both good escapement and fry abundance data and unfortunately there was only minimal information available. A counting fence is located above the hatchery, and above the main spawning area on the Quinsam River. The fence is monitored daily for brood stock collection in the fall, however, when the fence goes down, any upstream movement of salmonids is based on visual identification.

| Brood Year | Mean Fecundity | Female spawners | Est. # of Eggs | Juvenile Migrants | Egg to Fry Survival |
|---|---|---|---|---|---|
| 1988 | 6000 | 282 | 1,692,000 | 63,864 | 3.77% |
| 1989 | 6209 | 626 | 3,725,400 | 73,037 | 1.96% |
| 1990 | 6052 | 1157 | 7,002,164 | 26,297 | 0.38% |
| 1991[1] | 5918 | 297 | 1,757,646 | 13,864 | 0.80% |
| 1996 | 6000 | 8 | 48,000 | 2,161 | 4.50% |
| 1997 | 5495 | 131 | 719,845 | 42,684 | 5.93% |

[1]The Quinsam River hatchery had to suspend the operation of the downstream fence between 1993 to 1996 due to a funding shortfall.

According to Healey (1991), egg to fry survival for chinook ranges from 8% to 16%. Differences in the rates obtained may be due to low reliability in the numbers and sex of spawners above the fence. The male:female ratio above the fence may be skewed due to broodstock removals, and excess broodstock males being placed above the fence. There are no data on egg to fry survival rates for the rest of the system.

*Juvenile Interactions*

All hatchery chinook are presumed to migrate to the estuary shortly after release. Since both naturally reared chinook and hatchery reared chinook reach peak densities in the Campbell River estuary in late May, it is likely that most of the juvenile interaction occurs here (Levings *et al.* 1986; Korman *et al.* 1997). The estuarine habitat and productivity of the Campbell River system has been intensively studied (Macdonald *et al.* 1987; Levings *et al.* 1986; Bravender *et al.* 1997; McAllister and Brown, 1991; Korman *et al.* 1997; Brownlee *et al.* 1984,). These studies confirm the complexity of estuarine interactions (Burt and Burns, 1995).

Feeding patterns of juvenile chinook in the estuary and Discovery passage indicate a fluctuation in diet based upon abundance and availability of organisms. This implies that juvenile chinook eat a wide variety of prey and are opportunistic feeders (Kask *et al.* 1988; Brown *et al.* 1987a). Most studies also revealed that food sources are more abundant in the transition and marine zones (Brown *et al.* 1987a). Beach seine data from 1982 to 1986 found an inverse relationship between total biomass of salmonids and wild chinook fry growth. This indicates a density dependent competition for resources in the estuary (McAllister and Brown, 1991). It also indicates that the carrying capacity of the estuary may reach its limit during peak migration times (Burt and Burns, 1995). Korman *et al.* (1997) re-examined McAllister and Brown's results and added data from 1994. This study used Peterson mark-recapture techniques to determine the carrying capacity of the estuary. Results from this study re-affirmed McAllister and Brown's original findings supporting the contention that the growth of wild chinook in the Campbell River estuary may be density dependent.

Utilization of the estuarine habitat by naturally reared and hatchery chinook differs. Wild chinook fry densities were highest in estuarine zones while hatchery chinook densities were generally higher in the transition zone (Fig. 3). The chinook fry, both hatchery and wild, found in the transition zone were larger than those found in the estuarine zone (Mcdonald *et al.* 1987; Korman *et al.* 1997). Hatchery and naturally reared chinook also exhibited different estuarine residency times. The naturally reared chinook were present in the estuary for three months while hatchery chinook resided in the estuary for approximately 1.5 months (Korman, *et al.* 1997).

Residency of wild chinook fry in the transition zone lasts approximately 50 days. Peak wild fry density in the transition zone coincided with the peak in the estuarine zone. According to Levings *et al.* (1986) there is no lag between peak densities in the transition and the estuarine zones. The duration and the timing of the competition may be largely driven by hatchery releases (Korman *et al.* 1997).

**Seal Predation**

Although seal predation was not directly assessed in this report, there is anecdotal evidence that it may have a limited impact on Campbell/Quinsam River chinook populations. According to Bocking (1991) live tagging of chinook, for a Petersen mark-recapture program to estimate 1990 chinook escapement in the Campbell River estuary, was halted due to heavy seal predation on tagged releases. It is estimated that the current harbour seal herd in the estuary is in the range of 12-14 (S. Anderson, Quinsam Hatchery, pers. comm).

According to Olesiuk (1993), Pacific salmon make up about 4% of a harbour seal's annual diet. Within an estuary, the annual consumption of salmon may be as high as 12%. Harbour seals can be viewed as terminal predators of salmon with predation becoming more intense as salmon school in the estuary prior to upstream migration to spawn. The most abundant salmon species will be preyed on most heavily (Bigg *et. al* 1990). In other systems (Comox harbour), the predation rate of harbour seals on chinook salmon was estimated as high as 46%.

**Cohort Analyses of Coded-wire Tag Data**

Quantitative assessments of the Quinsam Hatchery/Campbell River chinook populations are heavily reliant on coded-wire tagging of chinook released from the Quinsam Hatchery since the 1974 brood year. Records of the tag groups applied and the recovery of those tags in coastwide fisheries are maintained at the Pacific Biological Station in the Mark Recovery database. Tag codes used to represent production from the Quinsam Hatchery are listed in Appendix B.

Cohort analysis is conducted using 'estimated' CWT recoveries to determine survival rates and exploitation patterns by brood years. Recoveries of tags in the spawning escapement at the hatchery and in the Quinsam and Campbell rivers allows estimation of the true total exploitation rates. The cohort model used is documented in Appendix 2 of Starr and Argue (1991) and as modified by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC, TCCHINOOK (99)-2). In determining incidental mortality, only the brood year method was used. The cohort model was modified by the CTC to account for the chinook non-retention fisheries implemented in Canada during 1996. Modifications are documented by the CTC in Appendix G of TCCHINOOK (99)-2.

For each brood year, information derived from the cohort analyses included:

- annual distribution of catch and total fishing mortalities;
- survival of CWT groups to Age-2 recruitment; and
- ocean (catch or total fishing mortality) and total exploitation rates by fishery and age.

**Distribution of Fishing Mortality** (Catch plus incidental mortality)

Quinsam/Campbell chinook are referred to as "Far-North" migrating fall chinook since they are caught in Alaskan fisheries and migrate back to their natal streams in the late summer and early autumn. Alaskan and northern BC fisheries encounter both immature feeding chinook and mature chinook, while more southerly fisheries primarily catch adults during their migration back to the Campbell River. The extent and distribution of fishing mortality has changed over time but the majority of mortality on this stock occurs in SE Alaskan fisheries and northern BC fisheries (Table 8). Mortality in fisheries more local to the Campbell River is less due to the northward migration of the immature chinook. Catches of this stock in the Johnstone Strait net and Strait of Georgia sport fisheries are primarily mature chinook during their return migration.

There have been limited in-river fishing opportunities in Campbell River in the past and there has been no recreational freshwater fishery since the 80's. There is also no in-river chinook harvest by First Nations.

**Exploitation Rates**

Exploitation rates can be estimated for catch only or can also include incidental moralities. The rates are estimated by fishery and age but have been combined for presentation. Figure 11 presents the time series of total exploitation rates (catch plus incidental mortality) and the portion of the mortality accounted for in ocean fisheries and terminal fisheries (total minus ocean values). Terminal fisheries include Age-4+ chinook caught in net fisheries and sport catch off the Campbell River. Total exploitation on this stock has decreased substantially since the 1970s. Previous to the 1985 Pacific Salmon Treaty, total exploitation had reached values exceeding 85% of the production from a brood year. Following the Treaty, total exploitation decreased to, on average, approximately 66%. Exploitation has decreased further in recent years due to conservation actions for west coast Vancouver Island chinook and southern BC coho salmon and terminal area closures. Extrapolated values for total exploitation on the most recent brood years, based on expanding observed returns by the average maturation rates at age, indicate total exploitation rates between 30 and 40%.

**Marine Survival Trends**

Returns to spawning escapement may vary depending on the exploitation pressures on a stock and/or variation in the ocean survival. The coded-wire tags released from Quinsam Hatchery allow for examination of both exploitation patterns (above) and comparison of marine survival between brood years. Marine survival is defined as the percentage of the tagged (CWT) smolts released from Quinsam Hatchery that survive to the Age-2 pre-fishery cohort and is estimated via cohort analysis.

The time series of marine survival rates for Quinsam Hatchery fall chinook is presented in Figure 12. Marine survival has varied by approximately 40 fold between brood years and was particularly poor during the 1989 through 1992 period. The most recent brood years indicate a marked improvement in survival but are based on incomplete data.

**Summary**

The Campbell River was historically one of the most important producers of chinook in the Strait of Georgia. Three over-riding key aspects were identified which have contributed to the decline of the Campbell River chinook stock. Hydro-electric development and associated construction of dams and water diversions are suggested to have significantly contributed to the decline of salmon stocks. Major changes in river discharge and flow regimes are known to have substantial detrimental effects to both the adult and juvenile life stages. Spawning areas used by salmon (chinook in particular) were surveyed in 1993 and a comparison with a previous survey conducted in 1973 indicated that less than 20% of the usable spawning areas remain. Secondly, the estuary has been used extensively by industry and for urban development which has been documented to have had a considerable impact on the rearing capacity for juveniles and the holding patterns for returning spawners. And finally, high exploitation of this stock in previous years at non-sustainable levels has obviously been detrimental to the natural chinook stock in the Campbell River.

Reduction in exploitation by approximately 50% since the late 70's and up to 400% improvements in marine survival in recent years should contribute substantially to the rebuilding process. In 1999, there were double the number of natural spawners in the Campbell River compared to the previous 5 years. It is suggested that in the next few years returns to the Campbell River could increase to 2000-3000. Significant reduction in the available natural spawning habitat in the Campbell River provides an opportunity to implement a full scale habitat assessment and determine limitations and changes to spawning distribution. In addition, further assessment should be conducted to determine the impact of exploitation levels on the enhanced and natural components of the stock with respect to spawning habitat limitations.

**Recommendations:**

1. A full scale habitat assessment be initiated for the Campbell River and mitigative measures be implemented. The minimum and maximum flow requirements to preserve spawning and rearing habitat needs to be revisited and an assessment of the total available spawning habitat made. (Some of this is already in progress)

2. The interim escapement goal needs to be reviewed with consideration given to a habitat-based approach.

3. Consideration should be given to a juvenile assessment program. Such a program could provide estimates of egg-fry survival and juvenile production, particularly for the Campbell River component. This could help to understand the relationship between freshwater conditions and juvenile production.

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Table 1. Historical mean monthly discharge (cu. m/sec) measured at the Island Highway, Campbell River[1].

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | - | - | - | - | - | - | - | - | - | - | - | 157 | --- |
| 1950 | 57.9 | 74.6 | 75.5 | 76.9 | 102 | 164 | 116 | 38.7 | 62 | 106 | 131 | 153 | 96.5 |
| 1951 | 115 | 74.7 | 34 | 88.1 | 116 | 60.5 | 46.8 | 38.1 | 38.9 | 87 | 84.5 | 71.4 | 71.2 |
| 1952 | 32.3 | 46.3 | 37.9 | 90.7 | 106 | 141 | 129 | 58.1 | 52.6 | 61.2 | 63.2 | 91.4 | 75.8 |
| 1953 | 137 | 108 | 48.6 | 56.2 | 140 | 125 | 120 | 70.9 | 70.2 | 88.6 | 277 | 144 | 115 |
| 1954 | 79.8 | 149 | 78.2 | 68.1 | 103 | 107 | 125 | 81.5 | 68.3 | - | 268 | 145 | --- |
| 1955 | 82.2 | 84.3 | - | - | 47.7 | 79.9 | 99.4 | 66.1 | 66.1 | 57.1 | 122 | 65.7 | --- |
| 1956 | 73.4 | 69.1 | 66.1 | 62 | 131 | 133 | 120 | 67.8 | 63.1 | 56.6 | 123 | 124 | 90.9 |
| 1957 | 65.3 | 70.5 | 64.4 | 56.8 | 27.3 | 20.7 | 23.6 | 34 | 29.1 | 51.8 | 51.6 | 31.9 | 43.7 |
| 1958 | 90.6 | 147 | 90.9 | 85.8 | 174 | 129 | 80.5 | 108 | 86.3 | 91.6 | 100 | 207 | 116 |
| 1959 | 117 | 95.5 | 88.6 | 87.4 | 120 | 180 | 85.5 | 79.6 | 80.2 | 78 | 83.5 | 99.9 | 99.5 |
| 1960 | 76.3 | 88.9 | 75.9 | 111 | 130 | 145 | 96.1 | 64.6 | 72.3 | 92 | 119 | 108 | 98.2 |
| 1961 | 241 | 183 | 113 | 101 | 120 | 152 | 98.9 | 72.3 | 71.9 | 71.2 | 80.4 | 66 | 114 |
| 1962 | 146 | 123 | 91 | 80.2 | 72.7 | 74.3 | 68.3 | 71.9 | 51.6 | 75 | 207 | 236 | 108 |
| 1963 | 116 | 127 | 76.7 | 103 | 80.6 | 88 | 96.1 | 76.6 | 74.9 | 139 | 168 | 193 | 111 |
| 1964 | 154 | 118 | 93.5 | 71.7 | 57.3 | 120 | 147 | 89.4 | 72.6 | 99.4 | 101 | 108 | 103 |
| 1965 | 118 | 111 | 74.3 | 59.9 | 53.5 | 61.7 | 67 | 66.8 | 55.1 | 72.8 | 140 | 172 | 87.5 |
| 1966 | 138 | 125 | 120 | 114 | 115 | 122 | 82.7 | 54.5 | 96 | 100 | 124 | 245 | 120 |
| 1967 | 132 | 128 | 121 | 122 | 70.3 | 116 | 97.6 | 73 | 68.1 | 140 | 141 | 158 | 114 |
| 1968 | 279 | 136 | 126 | 124 | 115 | 84.2 | 49 | 44.4 | 66 | 143 | 191 | 144 | 125 |
| 1969 | 123 | 79.8 | 88 | 111 | 125 | 188 | 119 | 92.9 | 100 | 109 | 118 | 126 | 115 |
| 1970 | 117 | 108 | 97.5 | 76.8 | 54.1 | 69.1 | 70 | 60.2 | 60.6 | 65.8 | 52.7 | 63.4 | 74.4 |
| 1992 | 233 | 198 | 102 | 82.2 | 67.4 | 50 | 61.1 | 42.6 | 40.2 | 80.9 | 111 | 119 | 98.7 |
| 1993 | 82 | 105 | 60.7 | 51.4 | 141 | 129 | 69.3 | 56.6 | 45 | 66.6 | 55.4 | 98.7 | 79.9 |
| 1994 | 120 | 130 | 124 | 118 | 116 | 45.5 | 51.1 | 51.3 | 53.9 | 99.2 | 78.9 | 96.3 | 90.1 |
| 1995 | 124 | 131 | 128 | 128 | 136 | 131 | 107 | 73.8 | 42.1 | 113 | 310 | 200 | 135 |
| 1997 | 178 | 108 | 115 | 103 | 103 | 81.7 | 67.9 | 32.4 | 52.6 | 115 | 104 | 76.4 | |
| 1961-70 mean | 156.40 | 123.88 | 100.10 | 96.36 | 86.35 | 107.53 | 89.56 | 70.20 | 71.68 | 101.52 | 132.31 | 151.14 | 107.19 |
| 1950-60 mean | 84.25 | 91.63 | 66.01 | 78.30 | 108.82 | 116.83 | 94.72 | 64.31 | 62.65 | 76.99 | 129.35 | 112.85 | 89.64 |
| 1992-97 mean | 122 | 112 | 86.5 | 88.6 | 101 | 109 | 89 | 65.3 | 63.5 | 89.4 | 132 | 132 | 99.2 |

[1] Information recorded by Water Survey Canada.
Apparently due to lack of funding, data was not recorded during the period between 1970-90.

Table 2. Chinook spawning capacity estimate in 1993 taken from Burt and Burns (1995).

**Table 10.** Estimation of chinook spawning capacity using spawning areas prorated by the proportion of suitably sized bed material.

| LOCATION | TOTAL AREA (sq m) | SUBSTRATE (%) (f/sg/lg/sc/lc/b) | % USABLE (lg+sc) | USABLE AREA (sq m) | # OF FEMALE SPAWNERS | COMMENTS (unless specified, comments are pers. comm. from D. Ewart, Quinsam Hatchery) |
|---|---|---|---|---|---|---|
| | | | Main Chinook Spawning Areas (Historic and Current): | | | |
| 1 | 2,816 | 0/2/5/15/26/52 (based on T4.5a) | 20% | 563 | 28 | Historic spawning area; currently supports limited spawning; substrate is mainly large cobble and boulder, gravel is sparse and in pockets; no chinook observed here in 1993. |
| 2 | 2,760 | 1/0/1/13/24/61 (based on T4.3) | 14% | 386 | 19 | Historically was main spawning area. Currently, limited spawning; substrate is mainly large cobble and boulder, gravel is sparse; no chinook observed here in 1993. |
| Total Main | 5,576 | | | 949 | 47 | |
| | | | Marginal Chinook Spawning Areas: | | | |
| 3 | 2,086 | 6/0/21/15/20/39 (based on T4.1b) | 36% | marginal | 10 | Gravel is shallow, large, and in pockets. Gravel placed in this side channel in 1985 is no longer present. |
| 4 | 1,769 | 23/15/19/20/16/08 (based on T3.4) | 39% | marginal | 10 | Gravel is abundant and unconsolidated but on the small size for chinook spawners - recruited from left bank 130 m upstream (author's observations). Used mainly by other species, although chinook spawn here in some years. No chinook observed here in 1993. |
| 6 | 3,537 | 0/5/9/19/34/32 (based on T3.1) | 38% | marginal | 10 | Limited spawning; shallow water; substrate mainly large cobble and boulder; gravel sparse and in pockets. Some chinook spawned here in 1993. |
| 7 | 1,874 | 22/8/12/15/15/30 (based on T2.4) | 27% | marginal | 10 | Tailout of Sandy Pool. Limited spawning; gravel is sparse. No chinook observed here in 1993 but some chinook spawning has occurred here in previous years. |
| 8 | 4,114 | 1/0/11/7/10/72 (based on T2.3) | 18% | marginal | 10 | Limited spawning; substrate mainly boulder; gravel sparse and in pockets. No chinook observed here in 1993 but have spawned here in the past. |
| 10 | 2,035 | 3/0/2/3/24/68 (based on T2.1) | 5% | marginal | 10 | Mainly a chum spawning area. Substrate is mainly large cobble and boulder, gravel is sparse. Up to 10 chinook pairs have been observed here in the past |
| 11 | 14,354 | 1/5/27/26/23/19 (based on T1.1) | 53% | marginal | 10 | Mainly a pink and chum spawning area. Available gravel is shallow and compacted making redd digging difficult. Some chinook have spawned here over the years. |
| Total Marginal | 29,769 | | | | 70 | |
| | | | Elk Falls Spawning Channel | | | |
| 5 | 1,176 | 0/0/18/69/08/05 (based on T3.3b) | 87% | 1,023 | 160 | 147 m long spawning channel; constructed 1992; mainly 5.1 cm gravel; in 1992 both ends blocked off and 157 females/162 males remained till spawning concerned. |
| Total Natural | 35,345 | | | 949 | 117 | |
| Total All | 36,521 | | | 1,972 | 277 | |

**Notes:**

"LOCATION" is from Figure 16.

"TOTAL AREA" is the total square meters of the spawning location as calculated by the GIS software QUIKMap.

"SUBSTRATE" is the percentages of fines (f), small gravel (sg), large gravel (lg), small cobble (sc), large cobble (lc), and boulder (b). Percentages are the average of cells from the portion of the transect within the indicated spawning location.

"% USABLE" is a rating of usable area based on the combined percentage of lg and sc in the substrate. This corresponds to a substrate size range of 1.6-12.8 cm, which approximates the preferred gravel size of 6-14 cm for spawning by ocean-type chinook (Beauchamp et al 1983).

"USABLE AREA" is "TOTAL AREA" prorated by the proportion with suitable substrate size ("% USABLE").

"NO. OF FEMALES" was derived by dividing "USABLE AREA" by the recommended square meters per spawning female. For ocean-type chinook the recommended spawning density is 20.1 sq m per female (Reiser and Bjornn 1979). The Elk Falls Spawning Channel was stocked with 157 females in 1992 resulting in a stocking density of 7.5 sq m per female (Dave Ewart, Quinsam Hatchery, pers. comm.). For marginal areas "NO OF FEMALES" was assumed to be 10.

Table 3. Quinsam Hatchery juvenile chinook releases by brood year, 1974-98.

| Tag Code | BY | Number Tagged | Number Released | CWT % Mark | Weigh (gm) | Release Date ddmmmyy:ddmmmyy | Release site |
|---|---|---|---|---|---|---|---|
| 20403 | 74 | 65683 | 162516 | 40.4 | 4.8 | :09Jun75 | 0106-QUINSAM R |
| 20108 | 75 | 99167 | 424567 | 23.4 | 4.3 | 10Jun76:18Jun76 | 0106-QUINSAM R |
| 21916 | 76 | 97123 | 376480 | 25.8 | 9.4 | 06Jun77:09Jun77 | 0106-QUINSAM R |
| 21736 | 77 | 50140 | 235443 | 21.3 | 7.4 | :05Jun78 | 0106-QUINSAM R |
| 21737 | 77 | 50707 | 319999 | 15.8 | 4 | :12Jun78 | 0106-QUINSAM R |
| 21738 | 77 | 51671 | 220945 | 23.4 | 4.5 | :05Jun78 | 0106-QUINSAM R |
| 21759 | 78 | 97316 | 849226 | 11.5 | 6.5 | 29May79:08Jun79 | 0106-QUINSAM R |
| 21757 | 79 | 51025 | 512663 | 10 | 7.1 | :29May80 | 0106-QUINSAM R |
| 21758 | 79 | 51819 | 568770 | 9.1 | 7.2 | :09Jun80 | 0106-QUINSAM R |
| 21657 | 80 | 52900 | 411885 | 12.8 | 7.3 | :21May81 | 0106-QUINSAM R |
| 21943 | 80 | 51220 | 381729 | 13.4 | 6.8 | :11May81 | 0106-QUINSAM R |
| 21950 | 80 | 52001 | 343164 | 15.2 | 7.7 | :03Jun81 | 0106-QUINSAM R |
| 22303 | 81 | 49802 | 180173 | 27.6 | 8.2 | :14May82 | 0106-QUINSAM R |
| 22304 | 81 | 49953 | 258233 | 19.3 | 7.9 | :04Jun82 | 0106-QUINSAM R |
| 82119 | 81 | 6693 | 7163 | 93.4 | 2.2 | :05May82 | 0106-QUINSAM R |
| 82120 | 81 | 9161 | 9373 | 97.7 | 2.4 | :05May82 | 0106-QUINSAM R |
| 82121 | 81 | 8739 | 8959 | 97.5 | 2.2 | :05May82 | 0106-QUINSAM R |
| 82122 | 81 | 9705 | 9961 | 97.4 | 2.7 | :05May82 | 0106-QUINSAM R |
| 82123 | 81 | 10006 | 10184 | 98.3 | 2.9 | :05May82 | 0106-QUINSAM R |
| 82124 | 81 | 10050 | 10214 | 98.4 | 3.2 | :05May82 | 0106-QUINSAM R |
| 82125 | 81 | 9475 | 10342 | 91.6 | 3.7 | :05May82 | 0106-QUINSAM R |
| 82126 | 81 | 9692 | 10359 | 93.6 | 3.7 | :05May82 | 0106-QUINSAM R |
| 82127 | 81 | 9583 | 10258 | 93.4 | 3.8 | :05May82 | 0106-QUINSAM R |
| 82128 | 81 | 9403 | 10111 | 93 | 5.3 | :26May82 | 0106-QUINSAM R |
| 82129 | 81 | 9553 | 10134 | 94.3 | 5.2 | :26May82 | 0106-QUINSAM R |
| 82130 | 81 | 9041 | 9906 | 91.3 | 5.5 | :26May82 | 0106-QUINSAM R |
| 82131 | 81 | 10156 | 10342 | 98.2 | 6.9 | :26May82 | 0106-QUINSAM R |
| 82132 | 81 | 10266 | 10426 | 98.5 | 6.9 | :26May82 | 0106-QUINSAM R |
| 82133 | 81 | 9730 | 9943 | 97.9 | 6.7 | :26May82 | 0106-QUINSAM R |
| 82134 | 81 | 10188 | 10288 | 99 | 8.4 | :26May82 | 0106-QUINSAM R |
| 82135 | 81 | 10364 | 10470 | 99 | 8.1 | :26May82 | 0106-QUINSAM R |
| 82136 | 81 | 10144 | 10144 | 100 | 8.2 | :26May82 | 0106-QUINSAM R |
| 82137 | 81 | 9434 | 10087 | 93.5 | 8.4 | :16Jun82 | 0106-QUINSAM R |
| 82138 | 81 | 9720 | 10330 | 94.1 | 7.8 | :16Jun82 | 0106-QUINSAM R |
| 82139 | 81 | 9356 | 9915 | 94.4 | 7.3 | :16Jun82 | 0106-QUINSAM R |
| 82140 | 81 | 10003 | 10210 | 98 | 10.4 | :16Jun82 | 0106-QUINSAM R |
| 82141 | 81 | 10389 | 10570 | 98.3 | 9.6 | :16Jun82 | 0106-QUINSAM R |
| 82142 | 81 | 9705 | 9934 | 97.7 | 8.9 | :16Jun82 | 0106-QUINSAM R |
| 82143 | 81 | 10575 | 10575 | 100 | 11.2 | :16Jun82 | 0106-QUINSAM R |
| 82144 | 81 | 10092 | 10092 | 100 | 12.3 | :16Jun82 | 0106-QUINSAM R |
| 82145 | 81 | 10038 | 10128 | 99.1 | 10.5 | :16Jun82 | 0106-QUINSAM R |
| 82146 | 81 | 9004 | 9738 | 92.5 | 10.2 | :07Jul82 | 0106-QUINSAM R |
| 82147 | 81 | 9186 | 10067 | 91.2 | 9.8 | :07Jul82 | 0106-QUINSAM R |
| 82149 | 81 | 9510 | 9681 | 98.2 | 13.4 | :07Jul82 | 0106-QUINSAM R |
| 82150 | 81 | 6815 | 6944 | 98.1 | 12.8 | :07Jul82 | 0106-QUINSAM R |
| 82152 | 81 | 9646 | 9646 | 100 | 16.5 | :07Jul82 | 0106-QUINSAM R |
| 82153 | 81 | 9158 | 9158 | 100 | 15.7 | :07Jul82 | 0106-QUINSAM R |
| 22518 | 82 | 36234 | 304401 | 11.9 | 8.5 | :16May83 | 0106-QUINSAM R |
| 22519 | 82 | 35375 | 283288 | 12.5 | 11.5 | :07Jun83 | 0106-QUINSAM R |
| 82046 | 82 | 9763 | 9959 | 98 | 5.1 | :05May83 | 0106-QUINSAM R |
| 82047 | 82 | 9846 | 10043 | 98 | 5.1 | :05May83 | 0106-QUINSAM R |
| 82048 | 82 | 10159 | 10363 | 98 | 5 | :05May83 | 0106-QUINSAM R |

Table 3 (cont.)

| Tag Code | BY | Number Tagged | Number Released | CWT % Mark | Weigh (gm) | Release Date ddmmmyy:ddmmmyy | Release site |
|---|---|---|---|---|---|---|---|
| 82049 | 82 | 10637 | 10850 | 98 | 6 | :05May83 | 0106-QUINSAM R |
| 82050 | 82 | 9803 | 9999 | 98 | 6 | :05May83 | 0106-QUINSAM R |
| 82051 | 82 | 9880 | 10078 | 98 | 6.1 | :05May83 | 0106-QUINSAM R |
| 82052 | 82 | 10221 | 10426 | 98 | 7.3 | :05May83 | 0106-QUINSAM R |
| 82053 | 82 | 9794 | 9990 | 98 | 6.9 | :05May83 | 0106-QUINSAM R |
| 82054 | 82 | 9812 | 10008 | 98 | 7 | :05May83 | 0106-QUINSAM R |
| 82055 | 82 | 10494 | 10673 | 98.3 | 8.1 | :26May83 | 0106-QUINSAM R |
| 82056 | 82 | 9855 | 10023 | 98.3 | 7.8 | :26May83 | 0106-QUINSAM R |
| 82057 | 82 | 9935 | 10104 | 98.3 | 7.4 | :26May83 | 0106-QUINSAM R |
| 82058 | 82 | 10014 | 10184 | 98.3 | 9.3 | :26May83 | 0106-QUINSAM R |
| 82059 | 82 | 9870 | 10038 | 98.3 | 9.1 | :26May83 | 0106-QUINSAM R |
| 82060 | 82 | 9932 | 10101 | 98.3 | 8.9 | :26May83 | 0106-QUINSAM R |
| 82061 | 82 | 9831 | 9998 | 98.3 | 10.7 | :26May83 | 0106-QUINSAM R |
| 82062 | 82 | 9882 | 10050 | 98.3 | 10.4 | :26May83 | 0106-QUINSAM R |
| 82063 | 82 | 10160 | 10333 | 98.3 | 10.3 | :26May83 | 0106-QUINSAM R |
| 82101 | 82 | 9915 | 10027 | 98.9 | 11 | :16Jun83 | 0106-QUINSAM R |
| 82102 | 82 | 10176 | 10291 | 98.9 | 10.9 | :16Jun83 | 0106-QUINSAM R |
| 82103 | 82 | 9884 | 9996 | 98.9 | 10.4 | :16Jun83 | 0106-QUINSAM R |
| 82104 | 82 | 9928 | 10041 | 98.9 | 12.8 | :16Jun83 | 0106-QUINSAM R |
| 82105 | 82 | 9946 | 10059 | 98.9 | 12.8 | :16Jun83 | 0106-QUINSAM R |
| 82106 | 82 | 9944 | 10057 | 98.9 | 12.8 | :16Jun83 | 0106-QUINSAM R |
| 82107 | 82 | 9937 | 10050 | 98.9 | 14.7 | :16Jun83 | 0106-QUINSAM R |
| 82108 | 82 | 9922 | 10034 | 98.9 | 14.5 | :16Jun83 | 0106-QUINSAM R |
| 82109 | 82 | 9954 | 10067 | 98.9 | 14 | :16Jun83 | 0106-QUINSAM R |
| 82110 | 82 | 9842 | 10082 | 97.6 | 14.1 | :07Jul83 | 0106-QUINSAM R |
| 82111 | 82 | 9822 | 10062 | 97.6 | 13.4 | :07Jul83 | 0106-QUINSAM R |
| 82112 | 82 | 9883 | 10124 | 97.6 | 13.6 | :07Jul83 | 0106-QUINSAM R |
| 82113 | 82 | 9872 | 10113 | 97.6 | 16.2 | :07Jul83 | 0106-QUINSAM R |
| 82114 | 82 | 9812 | 10052 | 97.6 | 16 | :07Jul83 | 0106-QUINSAM R |
| 82115 | 82 | 9875 | 10116 | 97.6 | 16 | :07Jul83 | 0106-QUINSAM R |
| 82148 | 82 | 10547 | 10784 | 97.8 | 18.7 | :07Jul83 | 0106-QUINSAM R |
| 82151 | 82 | 9816 | 10056 | 97.6 | 18.6 | :07Jul83 | 0106-QUINSAM R |
| 82154 | 82 | 10021 | 10266 | 97.6 | 18.7 | :07Jul83 | 0106-QUINSAM R |
| 82207 | 82 | 11096 | 11681 | 95 | 3.7 | :21Apr83 | 0106-QUINSAM R |
| 82208 | 82 | 11039 | 11621 | 95 | 3.7 | :21Apr83 | 0106-QUINSAM R |
| 82209 | 82 | 11021 | 11602 | 95 | 3.7 | :21Apr83 | 0106-QUINSAM R |
| 82210 | 82 | 11413 | 11646 | 98 | 3.6 | :21Apr83 | 0692-CAMPBELL R ESTUARY |
| 82211 | 82 | 11666 | 11905 | 98 | 3.6 | :21Apr83 | 0692-CAMPBELL R ESTUARY |
| 82212 | 82 | 11499 | 11734 | 98 | 3.6 | :21Apr83 | 0692-CAMPBELL R ESTUARY |
| 82214 | 82 | 11178 | 11645 | 96 | 3.2 | :21Apr83 | 0110-CAMPBELL TRANSITION |
| 82215 | 82 | 11107 | 11570 | 96 | 3.2 | :21Apr83 | 0110-CAMPBELL TRANSITION |
| 82216 | 82 | 11499 | 11654 | 98.7 | 3.2 | :21Apr83 | 0420-DISCOVERY PASS |
| 82217 | 82 | 11501 | 11656 | 98.7 | 3.2 | :21Apr83 | 0420-DISCOVERY PASS |
| 82218 | 82 | 11588 | 11744 | 98.7 | 3.2 | :21Apr83 | 0420-DISCOVERY PASS |
| 82219 | 82 | 11168 | 11634 | 96 | 3.2 | :21Apr83 | 0110-CAMPBELL TRANSITION |
| 22631 | 83 | 49499 | 669326 | 7.4 | 12.6 | 11Jun84:14Jun84 | 0106-QUINSAM R |
| 22632 | 83 | 50069 | 636553 | 7.9 | 14.1 | 08Jun84:09Jun84 | 0106-QUINSAM R |
| 82213 | 83 | 11666 | 11725 | 99.5 | 3 | :25Apr84 | 0131-DEEPWATER BAY |
| 82220 | 83 | 11649 | 11708 | 99.5 | 3 | :25Apr84 | 0131-DEEPWATER BAY |
| 82221 | 83 | 11621 | 11679 | 99.5 | 3 | :25Apr84 | 0131-DEEPWATER BAY |
| 82257 | 83 | 10814 | 11616 | 93.1 | 3.2 | :25Apr84 | 0106-QUINSAM R |
| 82258 | 83 | 10878 | 11688 | 93.1 | 3.2 | :25Apr84 | 0106-QUINSAM R |
| 82259 | 83 | 10834 | 11640 | 93.1 | 3.2 | :25Apr84 | 0106-QUINSAM R |

Table 3 (cont.)

| Tag Code | BY | Number Tagged | Number Released | CWT % Mark | Weigh (gm) | Release Date ddmmmyy:ddmmmyy | Release site |
|---|---|---|---|---|---|---|---|
| 82260 | 83 | 12173 | 12322 | 98.8 | 3.1 | :25Apr84 | 0692-CAMPBELL R ESTUARY |
| 82261 | 83 | 11633 | 11775 | 98.8 | 3.1 | :25Apr84 | 0692-CAMPBELL R ESTUARY |
| 82262 | 83 | 11465 | 11605 | 98.8 | 3.1 | :25Apr84 | 0692-CAMPBELL R ESTUARY |
| 82263 | 83 | 11833 | 11881 | 99.6 | 3 | :25Apr84 | 0110-CAMPBELL TRANSITION |
| 82301 | 83 | 11641 | 11688 | 99.6 | 3 | :25Apr84 | 0110-CAMPBELL TRANSITION |
| 82302 | 83 | 11617 | 11664 | 99.6 | 3 | :25Apr84 | 0110-CAMPBELL TRANSITION |
| 23322 | 84 | 24584 | 341464 | 7.2 | 12 | :31May85 | 0106-QUINSAM R |
| 23323 | 84 | 24538 | 340826 | 7.2 | 12 | :31May85 | 0106-QUINSAM R |
| 23324 | 84 | 24527 | 340672 | 7.2 | 12 | :31May85 | 0106-QUINSAM R |
| 23325 | 84 | 26157 | 331514 | 7.9 | 15.5 | 16Jun85:21Jun85 | 0106-QUINSAM R |
| 23326 | 84 | 24937 | 316051 | 7.9 | 15.5 | 16Jun85:21Jun85 | 0106-QUINSAM R |
| 23327 | 84 | 23714 | 300551 | 7.9 | 15.5 | 16Jun85:21Jun85 | 0106-QUINSAM R |
| 23328 | 84 | 24471 | 329345 | 7.4 | 14 | 14Jun85:24Jun85 | 0106-QUINSAM R |
| 23329 | 84 | 29676 | 399397 | 7.4 | 14 | 14Jun85:24Jun85 | 0106-QUINSAM R |
| 23330 | 84 | 24459 | 329183 | 7.4 | 14 | 14Jun85:24Jun85 | 0106-QUINSAM R |
| 82351 | 84 | 9657 | 10165 | 95 | 3.1 | :24Apr85 | 0106-QUINSAM R |
| 82352 | 84 | 10317 | 10860 | 95 | 3.1 | :24Apr85 | 0106-QUINSAM R |
| 82353 | 84 | 10039 | 10567 | 95 | 3.1 | :24Apr85 | 0106-QUINSAM R |
| 82354 | 84 | 10228 | 10823 | 94.5 | 3.1 | :24Apr85 | 0692-CAMPBELL R ESTUARY |
| 82355 | 84 | 10073 | 10659 | 94.5 | 3.1 | :24Apr85 | 0692-CAMPBELL R ESTUARY |
| 82356 | 84 | 9940 | 10519 | 94.5 | 3.1 | :24Apr85 | 0692-CAMPBELL R ESTUARY |
| 82357 | 84 | 10333 | 10803 | 95.6 | 3.1 | :24Apr85 | 0110-CAMPBELL TRANSITION |
| 82358 | 84 | 10132 | 10593 | 95.6 | 3.1 | :24Apr85 | 0110-CAMPBELL TRANSITION |
| 82359 | 84 | 10009 | 10464 | 95.7 | 3.1 | :24Apr85 | 0110-CAMPBELL TRANSITION |
| 82360 | 84 | 10577 | 10887 | 97.2 | 3.1 | :24Apr85 | 0131-DEEPWATER BAY |
| 82361 | 84 | 10342 | 10645 | 97.2 | 3.1 | :24Apr85 | 0131-DEEPWATER BAY |
| 82362 | 84 | 10281 | 10583 | 97.1 | 3.1 | :24Apr85 | 0131-DEEPWATER BAY |
| 23522 | 85 | 19954 | 338289 | 5.9 | 14.8 | :19Jun86 | 0106-QUINSAM R |
| 23523 | 85 | 19975 | 340054 | 5.9 | 14.8 | :19Jun86 | 0106-QUINSAM R |
| 23524 | 85 | 20127 | 341828 | 5.9 | 14.8 | :19Jun86 | 0106-QUINSAM R |
| 23525 | 85 | 20038 | 293886 | 6.8 | 12.1 | 10Jun86:15Jun86 | 0106-QUINSAM R |
| 23554 | 85 | 20110 | 294942 | 6.8 | 12.1 | 10Jun86:15Jun86 | 0106-QUINSAM R |
| 23555 | 85 | 20096 | 294736 | 6.8 | 12.1 | 10Jun86:15Jun86 | 0106-QUINSAM R |
| 23556 | 85 | 20145 | 304454 | 6.6 | 11.7 | 16Jun86:17Jun86 | 0106-QUINSAM R |
| 23557 | 85 | 20110 | 303925 | 6.6 | 11.7 | 16Jun86:17Jun86 | 0106-QUINSAM R |
| 23558 | 85 | 20096 | 303714 | 6.6 | 11.7 | 16Jun86:17Jun86 | 0106-QUINSAM R |
| 23645 | 85 | 24843 | 123350 | 20.1 | 11 | :29May86 | 0692-CAMPBELL R ESTUARY |
| 24017 | 85 | 23294 | 23294 | 100 | 10.3 | :18Jun86 | 0105-PUNTLEDGE R |
| 24018 | 85 | 24984 | 24984 | 100 | 10.3 | :18Jun86 | 0105-PUNTLEDGE R |
| 24152 | 86 | 19947 | 296538 | 6.7 | 7.1 | :08May87 | 0106-QUINSAM R |
| 24153 | 86 | 19935 | 296526 | 6.7 | 7.1 | :08May87 | 0106-QUINSAM R |
| 24154 | 86 | 19990 | 296581 | 6.7 | 7.1 | :08May87 | 0106-QUINSAM R |
| 24155 | 86 | 18978 | 486533 | 3.9 | 8.1 | 19May87:22May87 | 0106-QUINSAM R |
| 24156 | 86 | 20006 | 487561 | 4.1 | 8.1 | 19May87:22May87 | 0106-QUINSAM R |
| 24157 | 86 | 19982 | 487537 | 4.1 | 8.1 | 19May87:22May87 | 0106-QUINSAM R |
| 24158 | 86 | 19980 | 319493 | 6.3 | 9.9 | :27May87 | 0106-QUINSAM R |
| 24159 | 86 | 19899 | 319412 | 6.2 | 9.9 | :27May87 | 0106-QUINSAM R |
| 24160 | 86 | 19979 | 319492 | 6.3 | 9.9 | :27May87 | 0106-QUINSAM R |
| 24419 | 87 | 24457 | 357941 | 6.8 | 7.4 | :29Apr88 | 0106-QUINSAM R |
| 24420 | 87 | 24386 | 356906 | 6.8 | 7.4 | :29Apr88 | 0106-QUINSAM R |
| 24421 | 87 | 24486 | 358369 | 6.8 | 7.4 | :29Apr88 | 0106-QUINSAM R |
| 24736 | 87 | 20607 | 86118 | 23.9 | 7.7 | :11May88 | 2729-HIDDEN HARBOUR |
| 24737 | 87 | 20607 | 86118 | 23.9 | 7.7 | :11May88 | 2729-HIDDEN HARBOUR |

Table 3 (cont.)

| Tag Code | BY | Number Tagged | Number Released | CWT % Mark | Weigh (gm) | Release Date ddmmmyy:ddmmmyy | Release site |
|---|---|---|---|---|---|---|---|
| 24956 | 87 | 24641 | 355298 | 6.9 | 7.7 | :13May88 | 0106-QUINSAM R |
| 25324 | 87 | 24583 | 143705 | 17.1 | 10 | :26May88 | 0221-INDIAN ARM |
| 25325 | 87 | 24612 | 143735 | 17.1 | 10 | :26May88 | 0221-INDIAN ARM |
| 25358 | 87 | 24677 | 335041 | 7.4 | 6.6 | :06May88 | 0106-QUINSAM R |
| 25359 | 87 | 24727 | 335720 | 7.4 | 6.6 | :06May88 | 0106-QUINSAM R |
| 25360 | 87 | 24834 | 337174 | 7.4 | 6.6 | :06May88 | 0106-QUINSAM R |
| 25361 | 87 | 24504 | 353323 | 6.9 | 7.7 | :13May88 | 0106-QUINSAM R |
| 25362 | 87 | 24483 | 353019 | 6.9 | 7.7 | :13May88 | 0106-QUINSAM R |
| 25363 | 87 | 24222 | 75706 | 32 | 7.9 | :06May88 | 1305-APRIL PT |
| 25526 | 88 | 24624 | 207182 | 11.9 | 8.8 | :04May89 | 2729-HIDDEN HARBOUR |
| 25527 | 88 | 23937 | 268255 | 8.9 | 8.9 | :09May89 | 1305-APRIL PT |
| 25528 | 88 | 24329 | 279509 | 8.7 | 9.9 | :10May89 | 2421-TAKU LDG/QUADRA ISL |
| 25814 | 88 | 25246 | 314667 | 8 | 7.4 | :28Apr89 | 0106-QUINSAM R |
| 25815 | 88 | 25545 | 318334 | 8 | 7.4 | :28Apr89 | 0106-QUINSAM R |
| 25816 | 88 | 22344 | 278403 | 8 | 7.4 | :28Apr89 | 0106-QUINSAM R |
| 25817 | 88 | 25029 | 293909 | 8.5 | 5.7 | :21Apr89 | 0106-QUINSAM R |
| 25818 | 88 | 25096 | 294963 | 8.5 | 7.7 | :05May89 | 0106-QUINSAM R |
| 25819 | 88 | 25037 | 295995 | 8.5 | 9.2 | :18May89 | 0106-QUINSAM R |
| 25820 | 88 | 24810 | 431446 | 5.8 | 7.6 | 10May89:12May89 | 0106-QUINSAM R |
| 25821 | 88 | 24609 | 427950 | 5.8 | 7.6 | 10May89:12May89 | 0106-QUINSAM R |
| 25822 | 88 | 24884 | 432734 | 5.8 | 7.6 | 10May89:12May89 | 0106-QUINSAM R |
| 20354 | 89 | 23306 | 197636 | 11.8 | 10.2 | 04May90:04May90 | 2729-HIDDEN HARBOUR |
| 20355 | 89 | 22574 | 286523 | 7.9 | 8.9 | 06May90:06May90 | 1305-APRIL PT |
| 20356 | 89 | 23041 | 282580 | 8.2 | 8.6 | 03May90:03May90 | 2421-TAKU LDG/QUADRA ISL |
| 20357 | 89 | 23886 | 465403 | 5.1 | 6.5 | 26Apr90:07May90 | 0106-QUINSAM R |
| 20358 | 89 | 24634 | 473787 | 5.2 | 6.5 | 30Apr90:09May90 | 0106-QUINSAM R |
| 20359 | 89 | 24396 | 324505 | 7.5 | 5 | 23Apr90:24Apr90 | 0106-QUINSAM R |
| 20360 | 89 | 24499 | 316471 | 7.7 | 7.1 | 17May90:18May90 | 0106-QUINSAM R |
| 20361 | 89 | 24669 | 328077 | 7.5 | 6 | 04May90:05May90 | 0106-QUINSAM R |
| 20362 | 89 | 24418 | 599332 | 4.1 | 3 | 09Apr90:10Apr90 | 0105-PUNTLEDGE R |
| 26062 | 89 | 24929 | 219543 | 11.4 | 7.6 | 10May90:11May90 | 0106-QUINSAM R |
| 26063 | 89 | 24904 | 221242 | 11.3 | 6.3 | 10May90:11May90 | 0106-QUINSAM R |
| 26101 | 89 | 25007 | 442540 | 5.7 | 6.6 | 10May90:11May90 | 0106-QUINSAM R |
| 26102 | 89 | 24739 | 215726 | 11.5 | 6.6 | 10May90:11May90 | 0106-QUINSAM R |
| 20956 | 90 | 26953 | 216107 | 12.5 | 7.7 | :09May91 | 0106-QUINSAM R |
| 20957 | 90 | 26752 | 456930 | 5.9 | 7.2 | :09May91 | 0106-QUINSAM R |
| 20958 | 90 | 26658 | 232453 | 11.5 | 8 | :09May91 | 0106-QUINSAM R |
| 20959 | 90 | 25870 | 229390 | 11.3 | 7.2 | :09May91 | 0106-QUINSAM R |
| 21448 | 90 | 26509 | 523459 | 5.1 | 5.6 | 25Apr91:29Apr91 | 0106-QUINSAM R |
| 21449 | 90 | 26602 | 359229 | 7.4 | 4.6 | :19Apr91 | 0106-QUINSAM R |
| 21450 | 90 | 26384 | 357439 | 7.4 | 6.6 | :02May91 | 0106-QUINSAM R |
| 21451 | 90 | 26502 | 346999 | 7.6 | 7.8 | :16May91 | 0106-QUINSAM R |
| 26016 | 90 | 27211 | 616103 | 4.4 | 7.6 | :02May91 | 1305-APRIL PT |
| 26017 | 90 | 25911 | 310172 | 8.4 | 7.1 | 02May91:03May91 | 0420-DISCOVERY PASS |
| 26018 | 90 | 28265 | 212169 | 13.3 | 8.1 | :01May91 | 2421-TAKU LDG/QUADRA ISL |
| 26019 | 90 | 26817 | 529541 | 5.1 | 5.5 | 25Apr91:29Apr91 | 0106-QUINSAM R |
| 21328 | 91 | 24770 | 316126 | 7.8 | 10.6 | :13May92 | 0420-DISCOVERY PASS |
| 21329 | 91 | 24661 | 623650 | 4 | 10.8 | :13May92 | 1305-APRIL PT |
| 21330 | 91 | 20328 | 207158 | 9.8 | 12.1 | :14May92 | 0462-DREW HB CR |
| 21331 | 91 | 24593 | 551333 | 4.5 | 6.3 | :26Apr92 | 0106-QUINSAM R |
| 180415 | 91 | 24676 | 554177 | 4.5 | 5.8 | :23Apr92 | 0106-QUINSAM R |
| 180416 | 91 | 23951 | 327065 | 7.3 | 5 | :20Apr92 | 0106-QUINSAM R |
| 180417 | 91 | 24967 | 342823 | 7.3 | 8.4 | :19May92 | 0106-QUINSAM R |

Table 3 (cont.)

| Tag Code | BY | Number Tagged | Number Released | CWT % Mark | Weigh (gm) | Release Date ddmmmyy:ddmmmyy | Release site |
|---|---|---|---|---|---|---|---|
| 180418 | 91 | 24864 | 338271 | 7.4 | 6.4 | :27Apr92 | 0106-QUINSAM R |
| 180419 | 91 | 24709 | 210451 | 11.7 | 7.6 | :04May92 | 0106-QUINSAM R |
| 180420 | 91 | 24952 | 460518 | 5.4 | 7.9 | :04May92 | 0106-QUINSAM R |
| 180421 | 91 | 23760 | 220124 | 10.8 | 7.1 | :04May92 | 0106-QUINSAM R |
| 180422 | 91 | 24936 | 250990 | 9.9 | 8.2 | :04May92 | 0106-QUINSAM R |
| 181147 | 92 | 24925 | 250826 | 9.9 | 7.8 | :13May93 | 2421-TAKU LDG/QUADRA ISL |
| 181148 | 92 | 23730 | 230851 | 10.3 | 7.6 | :19May93 | 0008-MENZIES BAY |
| 181149 | 92 | 24128 | 431813 | 5.6 | 6.7 | :13May93 | 1305-APRIL PT |
| 181150 | 92 | 24983 | 495041 | 5 | 4.4 | :22Apr93 | 0106-QUINSAM R |
| 181151 | 92 | 24731 | 490046 | 5 | 4.4 | :24Apr93 | 0106-QUINSAM R |
| 181152 | 92 | 24932 | 289532 | 8.6 | 3.7 | :19Apr93 | 0106-QUINSAM R |
| 181153 | 92 | 24450 | 288441 | 8.5 | 4.1 | :27Apr93 | 0106-QUINSAM R |
| 181154 | 92 | 23689 | 266462 | 8.9 | 6.5 | :19May93 | 0106-QUINSAM R |
| 181155 | 92 | 24123 | 222938 | 10.8 | 6 | :13May93 | 0106-QUINSAM R |
| 181156 | 92 | 24228 | 445162 | 5.4 | 7.2 | :13May93 | 0106-QUINSAM R |
| 181157 | 92 | 24101 | 214271 | 11.2 | 7.8 | :13May93 | 0106-QUINSAM R |
| 181158 | 92 | 23382 | 218204 | 10.7 | 7 | :13May93 | 0106-QUINSAM R |
| 180628 | 93 | 25362 | 231105 | 11 | 6.2 | :06May94 | 0420-DISCOVERY PASS |
| 180629 | 93 | 26632 | 142600 | 18.7 | 6.8 | :18May94 | 0106-QUINSAM R |
| 180630 | 93 | 26322 | 289207 | 9.1 | 5.8 | :18May94 | 0106-QUINSAM R |
| 180631 | 93 | 26719 | 285755 | 9.4 | 5.7 | :18May94 | 0106-QUINSAM R |
| 181356 | 93 | 26204 | 89928 | 29.1 | 6.8 | :03May94 | 2729-HIDDEN HARBOUR |
| 181357 | 93 | 26140 | 104505 | 25 | 7.5 | :12May94 | 0106-QUINSAM R |
| 181358 | 93 | 26574 | 108298 | 24.5 | 6.7 | :12May94 | 0106-QUINSAM R |
| 181359 | 93 | 25147 | 199756 | 12.6 | 6.6 | :12May94 | 0106-QUINSAM R |
| 181360 | 93 | 25631 | 205957 | 12.4 | 5.9 | :12May94 | 0106-QUINSAM R |
| 181361 | 93 | 26115 | 203120 | 12.9 | 6.6 | :12May94 | 0106-QUINSAM R |
| 181362 | 93 | 26370 | 214480 | 12.3 | 6.7 | :12May94 | 0106-QUINSAM R |
| 20960 | 94 | 24880 | 229164 | 10.9 | 6.3 | :05May95 | 1305-APRIL PT |
| 20961 | 94 | 24769 | 229650 | 10.8 | 5.4 | :10May95 | 0008-MENZIES BAY |
| 20962 | 94 | 24997 | 228417 | 10.9 | 7.4 | :11May95 | 2421-TAKU LDG/QUADRA ISL |
| 20963 | 94 | 26086 | 250492 | 10.4 | 5.1 | 04May95:10May95 | 0420-DISCOVERY PASS |
| 181644 | 94 | 25528 | 110751 | 23 | 7.8 | :10May95 | 0106-QUINSAM R |
| 181645 | 94 | 25946 | 106226 | 24.4 | 6.5 | :12May95 | 0106-QUINSAM R |
| 181646 | 94 | 26471 | 219488 | 12.1 | 7.2 | :10May95 | 0106-QUINSAM R |
| 181647 | 94 | 26470 | 215557 | 12.3 | 6.6 | :10May95 | 0106-QUINSAM R |
| 181648 | 94 | 26529 | 211392 | 12.5 | 5.9 | :10May95 | 0106-QUINSAM R |
| 181649 | 94 | 26438 | 219269 | 12.1 | 5.8 | :10May95 | 0106-QUINSAM R |
| 181650 | 94 | 26397 | 152759 | 17.3 | 6.8 | :17May95 | 0106-QUINSAM R |
| 181651 | 94 | 26375 | 294063 | 9 | 6.5 | :17May95 | 0106-QUINSAM R |
| 181652 | 94 | 26770 | 301171 | 8.9 | 5.7 | :17May95 | 0106-QUINSAM R |
| 181658 | 95 | 24689 | 233165 | 10.6 | 7.9 | 21May96:23May96 | 0106-QUINSAM R |
| 181659 | 95 | 26388 | 236219 | 11.2 | 9.1 | 21May96:23May96 | 0106-QUINSAM R |
| 181660 | 95 | 26620 | 238597 | 11.2 | 9.9 | 21May96:23May96 | 0106-QUINSAM R |
| 181661 | 95 | 26120 | 147472 | 17.7 | 2.3 | :31May96 | 0210-QUINSAM R UP |
| 182016 | 95 | 25543 | 130479 | 19.6 | 8.1 | 14May96:15May96 | 0106-QUINSAM R |
| 182017 | 95 | 25494 | 50230 | 50.8 | 7.8 | :03May96 | 6124-ELK FALLS CH #1 |
| 182018 | 95 | 25587 | 134370 | 19 | 8.4 | 14May96:15May96 | 0106-QUINSAM R |
| 182019 | 95 | 25561 | 268923 | 9.5 | 11 | :09May96 | 1305-APRIL PT |
| 182020 | 95 | 26187 | 214864 | 12.2 | 8.2 | 14May96:15May96 | 0106-QUINSAM R |
| 182021 | 95 | 26084 | 217582 | 12 | 8.7 | 14May96:15May96 | 0106-QUINSAM R |
| 182022 | 95 | 25392 | 533324 | 4.8 | 6 | 03May96:03May96 | 0420-DISCOVERY PASS |
| 181830 | 96 | 29220 | 205638 | 14.2 | 7.5 | :20May97 | 0106-QUINSAM R |

Table 3 (cont.)

| Tag Code | BY | Number Tagged | Number Released | CWT % Mark | Weigh (gm) | Release Date ddmmmyy:ddmmmyy | Release site |
|---|---|---|---|---|---|---|---|
| 181831 | 96 | 28465 | 179524 | 15.9 | 10.2 | :18Jul97 | 1305-APRIL PT |
| 182509 | 96 | 23689 | 532576 | 4.4 | 8.7 | :01May97 | 0420-DISCOVERY PASS |
| 182510 | 96 | 21449 | 267744 | 8 | 10 | :13May97 | 0420-DISCOVERY PASS |
| 182511 | 96 | 26826 | 533065 | 5 | 7.6 | :02May97 | 1305-APRIL PT |
| 182512 | 96 | 27938 | 296595 | 9.4 | 7.1 | :13May97 | 0106-QUINSAM R |
| 182513 | 96 | 28013 | 292127 | 9.6 | 7.8 | :13May97 | 0106-QUINSAM R |
| 182514 | 96 | 28770 | 302936 | 9.5 | 9.1 | :13May97 | 0106-QUINSAM R |
| 182515 | 96 | 28914 | 215252 | 13.4 | 8.2 | :20May97 | 0106-QUINSAM R |
| 182516 | 96 | 28956 | 214421 | 13.5 | 8.5 | :20May97 | 0106-QUINSAM R |
| 182517 | 96 | 29422 | 213776 | 13.8 | 8.5 | :20May97 | 0106-QUINSAM R |
| 182518 | 96 | 27933 | 219585 | 12.7 | 7.8 | :20May97 | 0106-QUINSAM R |
| 183031 | 97 | 29371 | 223582 | 13.1 | 10.6 | :08May98 | 0420-DISCOVERY PASS |
| 183032 | 97 | 28507 | 223721 | 12.7 | 10.5 | :11May98 | 1305-APRIL PT |
| 183033 | 97 | 26852 | 219735 | 12.2 | 9.7 | :11May98 | 1305-APRIL PT |
| 183034 | 97 | 26370 | 198991 | 13.3 | 9.4 | :15May98 | 0420-DISCOVERY PASS |
| 183035 | 97 | 28852 | 182479 | 15.8 | 9 | :20May98 | 0106-QUINSAM R |
| 183036 | 97 | 28609 | 218581 | 13.1 | 8.9 | :13May98 | 0106-QUINSAM R |
| 183037 | 97 | 29172 | 215456 | 13.5 | 8.2 | :13May98 | 0106-QUINSAM R |
| 183038 | 97 | 29371 | 220305 | 13.3 | 7.7 | :13May98 | 0106-QUINSAM R |
| 183039 | 97 | 30284 | 174073 | 17.4 | 8.8 | :20May98 | 0106-QUINSAM R |
| 183040 | 97 | 29850 | 257859 | 11.6 | 8.8 | :20May98 | 0106-QUINSAM R |
| 183041 | 97 | 30389 | 253480 | 12 | 9.1 | :27May98 | 0106-QUINSAM R |
| 183042 | 97 | 29825 | 203185 | 14.7 | 6.1 | :06May98 | 0106-QUINSAM R |
| 183735 | 98 | 24891 | 266431 | 9.3 | 8.1 | 30Apr99:30Apr99 | 0420-DISCOVERY PASS |
| 183736 | 98 | 28222 | 270118 | 10.4 | 6.6 | :29Apr99 | 0420-DISCOVERY PASS |
| 183737 | 98 | 29121 | 269647 | 10.8 | 7.4 | :06May99 | 0420-DISCOVERY PASS |
| 183738 | 98 | 30058 | 267362 | 11.2 | 5.6 | 22Apr99:27Apr99 | 0592-CAMPBELL R ESTUARY |
| 183739 | 98 | 27213 | 227236 | 12 | 9 | :10May99 | 0106-QUINSAM R |
| 183740 | 98 | 29374 | 220556 | 13.3 | 9.3 | :11May99 | 0106-QUINSAM R |
| 183741 | 98 | 26350 | 310849 | 8.5 | 8.8 | :12May99 | 0106-QUINSAM R |
| 183742 | 98 | 24768 | 309962 | 8 | 8.8 | :14May99 | 0106-QUINSAM R |
| 183743 | 98 | 25438 | 309559 | 8.2 | 8.7 | :20May99 | 0106-QUINSAM R |
| 183744 | 98 | 28316 | 443601 | 6.4 | 8.5 | 17May99:18May99 | 0106-QUINSAM R |
| 183745 | 98 | 28924 | 393859 | 7.3 | 7.7 | 06May99:07May99 | 0106-QUINSAM R |
| 183746 | 98 | 30048 | 150212 | 20 | 6.3 | 03May99:10May99 | 0420-DISCOVERY PASS |

Table 4. Quinsam Hatchery expanded CWT recoveries for chinook escapement by return year, age and sex.

| | | | Age | | | | | | | | Chinook | Chinook |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rec Yr | Class | Area | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Grand Total | Jacks | Adults |
| 1977 | Adult Unk | HATCHERY | | | 31.55 | | | 28.13 | | 59.68 | 0 | 59.68 |
| | Adult Unk Total | | | | 31.55 | | | 28.13 | | 59.68 | 0 | 59.68 |
| 1977 Total | | | | | 31.55 | | | 28.13 | | 59.68 | 0 | 59.68 |
| 1978 | Adult Unk | BELOW FENCE | | | | 10.97 | | | | 10.97 | 0 | 10.97 |
| | | HATCHERY | | | | 44.54 | | | | 44.54 | 0 | 44.54 |
| | Adult Unk Total | | | | | 55.51 | | | | 55.51 | 0 | 55.51 |
| 1978 Total | | | | | | 55.51 | | | | 55.51 | 0 | 55.51 |
| 1979 | Adult Unk | BELOW FENCE | | | 11.63 | 29.97 | 118.76 | | | 160.36 | 0 | 160.36 |
| | | HATCHERY | | | 47.74 | 35.15 | 139.66 | | | 223.58 | 0 | 223.58 |
| | Adult Unk Total | | | | 59.37 | 65.12 | 258.42 | | | 383.94 | 0 | 383.94 |
| 1979 Total | | | | | 59.37 | 65.12 | 258.42 | | | 383.94 | 0 | 383.94 |
| 1980 | Adult Unk | BELOW FENCE | | | | 291 | 53.57 | 6.19 | | 350.76 | 0 | 350.76 |
| | | HATCHERY | | 9.6 | 38.12 | 319.8 | 61.22 | 8.17 | | 436.91 | 9.6 | 427.31 |
| | Adult Unk Total | | | 9.6 | 38.12 | 610.8 | 114.79 | 14.36 | | 787.67 | 9.6 | 778.07 |
| 1980 Total | | | | 9.6 | 38.12 | 610.8 | 114.79 | 14.36 | | 787.67 | 9.6 | 778.07 |
| 1981 | Adult Unk | BELOW FENCE | | | | 155.84 | 723.7 | | | 879.54 | 0 | 879.54 |
| | | HATCHERY | | 11.12 | 26.52 | 39.26 | 255.23 | | | 332.13 | 11.12 | 321.01 |
| | Adult Unk Total | | | 11.12 | 26.52 | 195.1 | 978.93 | | | 1211.67 | 11.12 | 1200.55 |
| 1981 Total | | | | 11.12 | 26.52 | 195.1 | 978.93 | | | 1211.67 | 11.12 | 1200.55 |
| 1982 | Adult Unk | BELOW FENCE | | | 59.92 | 364.33 | 390.29 | 23.12 | | 837.66 | 0 | 837.66 |
| | | HATCHERY | | 37.92 | 27.72 | 349.48 | 112.36 | 6.53 | | 534.01 | 37.92 | 496.09 |
| | Adult Unk Total | | | 37.92 | 87.64 | 713.81 | 502.65 | 29.65 | | 1371.67 | 37.92 | 1333.75 |
| 1982 Total | | | | 37.92 | 87.64 | 713.81 | 502.65 | 29.65 | | 1371.67 | 37.92 | 1333.75 |
| 1983 | Adult Unk | ABOVE FENCE | | | | 1.77 | 18.46 | | | 20.23 | 0 | 20.23 |
| | | BELOW FENCE | | | | 46.19 | 481.46 | | | 527.65 | 0 | 527.65 |
| | | HATCHERY | 0.85 | 18.81 | 57.18 | 191.44 | 281.73 | | | 550.01 | 19.66 | 530.35 |
| | Adult Unk Total | | 0.85 | 18.81 | 57.18 | 239.4 | 781.65 | | | 1097.89 | 19.66 | 1078.23 |
| 1983 Total | | | 0.85 | 18.81 | 57.18 | 239.4 | 781.65 | | | 1097.89 | 19.66 | 1078.23 |
| 1984 | Adult Fem | ABOVE FENCE | | | | 169.8 | 193.86 | 17.97 | | 381.63 | 0 | 381.63 |
| | | HATCHERY | | | | 409.04 | 180.09 | 17.45 | | 606.58 | 0 | 606.58 |
| | Adult Fem Total | | | | | 578.84 | 373.95 | 35.42 | | 988.21 | 0 | 988.21 |
| | Adult Male | BELOW FENCE | | 32.68 | 48.42 | 302.76 | 67.14 | | | 451 | 32.68 | 418.32 |
| | | HATCHERY | 35.23 | 100.67 | 144.53 | 405.95 | 116.52 | 8.06 | | 810.96 | 135.9 | 675.06 |
| | Adult Male Total | | 35.23 | 133.35 | 192.95 | 708.71 | 183.66 | 8.06 | | 1261.96 | 168.58 | 1093.38 |
| 1984 Total | | | 35.23 | 133.35 | 192.95 | 1287.55 | 557.61 | 43.48 | | 2250.17 | 168.58 | 2081.59 |
| | | | | | | | | | | | | |
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Table 4 (cont.)

| | | | Age | | | | | | | | Chinook | Chinook |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rec Yr | Class | Area | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Grand Total | Jacks | Adults |
| 1985 | Adult Fem | BELOW FENCE | | | 1.79 | 182.81 | 472.87 | 35.48 | | 692.95 | 0 | 692.95 |
| | | HATCHERY | | | 12.61 | 246.51 | 368.94 | 20.33 | | 648.39 | 0 | 648.39 |
| | Adult Fem Total | | | | 14.4 | 429.32 | 841.81 | 55.81 | | 1341.34 | 0 | 1341.34 |
| | Adult Male | BELOW FENCE | | | 55.78 | 361.78 | 81.46 | | | 499.02 | 0 | 499.02 |
| | | HATCHERY | | 77.69 | 308.78 | 557.06 | 150.9 | 10.23 | | 1104.66 | 77.69 | 1026.97 |
| | Adult Male Total | | | 77.69 | 364.56 | 918.84 | 232.36 | 10.23 | | 1603.68 | 77.69 | 1525.99 |
| | Adult Unk | ABOVE FENCE | | 1.8 | 7.36 | 18.62 | 12.07 | 0.71 | | 40.56 | 1.8 | 38.76 |
| | Adult Unk Total | | | 1.8 | 7.36 | 18.62 | 12.07 | 0.71 | | 40.56 | 1.8 | 38.76 |
| 1985 Total | | | | 79.49 | 386.32 | 1366.78 | 1086.24 | 66.75 | | 2985.58 | 79.49 | 2906.09 |
| 1986 | Adult Fem | BELOW FENCE | | | | 109.59 | 242.88 | | | 352.47 | 0 | 352.47 |
| | | HATCHERY | | | | 393.56 | 266 | 15.69 | | 675.25 | 0 | 675.25 |
| | Adult Fem Total | | | | | 503.15 | 508.88 | 15.69 | | 1027.72 | 0 | 1027.72 |
| | Adult Male | BELOW FENCE | | 23.37 | 52.24 | 207.13 | 69.66 | | | 352.4 | 23.37 | 329.03 |
| | | HATCHERY | | 66.9 | 311.72 | 468.62 | 71.14 | | | 918.38 | 66.9 | 851.48 |
| | Adult Male Total | | | 90.27 | 363.96 | 675.75 | 140.8 | | | 1270.78 | 90.27 | 1180.51 |
| | Adult Unk | ABOVE FENCE | | 0.56 | 2.65 | 7.44 | 2.96 | 0.14 | | 13.75 | 0.56 | 13.19 |
| | Adult Unk Total | | | 0.56 | 2.65 | 7.44 | 2.96 | 0.14 | | 13.75 | 0.56 | 13.19 |
| 1986 Total | | | | 90.83 | 366.61 | 1186.34 | 652.64 | 15.83 | | 2312.25 | 90.83 | 2221.42 |
| 1987 | Adult Fem | BELOW FENCE | | | 21.38 | 155.12 | 319.81 | 84.39 | | 580.7 | 0 | 580.7 |
| | | HATCHERY | | | 13.94 | 249.53 | 551.09 | 44.78 | | 859.34 | 0 | 859.34 |
| | Adult Fem Total | | | | 35.32 | 404.65 | 870.9 | 129.17 | | 1440.04 | 0 | 1440.04 |
| | Adult Male | BELOW FENCE | | | 648.44 | 304.33 | 217.82 | 7.47 | | 1178.06 | 0 | 1178.06 |
| | | HATCHERY | | 14.61 | 1096.11 | 416.58 | 237.55 | 10.27 | | 1775.12 | 14.61 | 1760.51 |
| | Adult Male Total | | | 14.61 | 1744.55 | 720.91 | 455.37 | 17.74 | | 2953.18 | 14.61 | 2938.57 |
| | Adult Unk | ABOVE FENCE | | 0.13 | 10.03 | 6.01 | 7.1 | 0.52 | | 23.79 | 0.13 | 23.66 |
| | Adult Unk Total | | | 0.13 | 10.03 | 6.01 | 7.1 | 0.52 | | 23.79 | 0.13 | 23.66 |
| 1987 Total | | | | 14.74 | 1789.9 | 1131.57 | 1333.37 | 147.43 | | 4417.01 | 14.74 | 4402.27 |
| 1988 | Adult Fem | BELOW FENCE | | | | 1278.28 | 549.6 | 33.34 | | 1861.22 | 0 | 1861.22 |
| | | HATCHERY | | | | 1197.1 | 325.19 | 37.6 | | 1559.89 | 0 | 1559.89 |
| | Adult Fem Total | | | | | 2475.38 | 874.79 | 70.94 | | 3421.11 | 0 | 3421.11 |
| | Adult Male | BELOW FENCE | | | 88.69 | 1905.19 | 372.75 | | 8.21 | 2374.84 | 0 | 2374.84 |
| | | HATCHERY | | 129.67 | 185.65 | 1844.72 | 110.38 | 1.83 | | 2272.25 | 129.67 | 2142.58 |
| | Adult Male Total | | | 129.67 | 274.34 | 3749.91 | 483.13 | 1.83 | 8.21 | 4647.09 | 129.67 | 4517.42 |
| | Adult Unk | ABOVE FENCE | | 19.28 | 27.58 | 454.2 | 65.3 | 5.92 | | 572.28 | 19.28 | 553 |
| | Adult Unk Total | | | 19.28 | 27.58 | 454.2 | 65.3 | 5.92 | | 572.28 | 19.28 | 553 |
| 1988 Total | | | | 148.95 | 301.92 | 6679.49 | 1423.22 | 78.69 | 8.21 | 8640.48 | 148.95 | 8491.53 |
| | | | | | | | | | | | | |
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| | | | | | | | | | | | | |

Table 4 (cont.)

| Rec Yr | Class | Area | Age 1 | 2 | 3 | 4 | 5 | 6 | 7 | Grand Total | Chinook Jacks | Chinook Adults |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1989 | Adult Fem | ABOVE FENCE | | | | | 386.09 | | | 386.09 | 0 | 386.09 |
| | | BELOW FENCE | | | | 313.86 | 2364.87 | 1.54 | | 2680.27 | 0 | 2680.27 |
| | | HATCHERY | | | 57.64 | 55.27 | 1528.1 | | | 1641.01 | 0 | 1641.01 |
| | Adult Fem Total | | | | 57.64 | 369.13 | 4279.06 | 1.54 | | 4707.37 | 0 | 4707.37 |
| | Adult Male | ABOVE FENCE | | | | 80.6 | 363.15 | | | 443.75 | 0 | 443.75 |
| | | BELOW FENCE | | 24.98 | 772.83 | 611.69 | 1112.6 | | | 2522.1 | 24.98 | 2497.12 |
| | | HATCHERY | | 14.3 | 1670.95 | 446.33 | 534.93 | | | 2666.51 | 14.3 | 2652.21 |
| | Adult Male Total | | | 39.28 | 2443.78 | 1138.62 | 2010.68 | | | 5632.36 | 39.28 | 5593.08 |
| 1989 Total | | | | 39.28 | 2501.42 | 1507.75 | 6289.74 | 1.54 | | 10339.73 | 39.28 | 10300.45 |
| 1990 | Adult Fem | BELOW FENCE | | | | 1107.36 | 1113.04 | 153.49 | | 2373.89 | 0 | 2373.89 |
| | | HATCHERY | | | | 488.3 | 106.85 | 21.71 | | 616.86 | 0 | 616.86 |
| | Adult Fem Total | | | | | 1595.66 | 1219.89 | 175.2 | | 2990.75 | 0 | 2990.75 |
| | Adult Male | BELOW FENCE | | | 127.53 | 943.3 | 294.58 | 2.32 | | 1367.73 | 0 | 1367.73 |
| | | HATCHERY | | 31.24 | 116.36 | 908.15 | | | | 1055.75 | 31.24 | 1024.51 |
| | Adult Male Total | | | 31.24 | 243.89 | 1851.45 | 294.58 | 2.32 | | 2423.48 | 31.24 | 2392.24 |
| | Adult Unk | ABOVE FENCE | | 28 | 104.25 | 1259.14 | 97.46 | 19.81 | | 1508.66 | 28 | 1480.66 |
| | Adult Unk Total | | | 28 | 104.25 | 1259.14 | 97.46 | 19.81 | | 1508.66 | 28 | 1480.66 |
| 1990 Total | | | | 59.24 | 348.14 | 4706.25 | 1611.93 | 197.33 | | 6922.89 | 59.24 | 6863.65 |
| 1991 | Adult Fem | ABOVE FENCE | | | | 103.25 | 164.13 | | | 267.38 | 0 | 267.38 |
| | | BELOW FENCE | | | | 486.64 | 697.21 | 7.36 | | 1191.21 | 0 | 1191.21 |
| | | HATCHERY | | | | 374.89 | 595.91 | | | 970.8 | 0 | 970.8 |
| | Adult Fem Total | | | | | 964.78 | 1457.25 | 7.36 | | 2429.39 | 0 | 2429.39 |
| | Adult Male | ABOVE FENCE | 1.73 | | 71.17 | 139.09 | 41.25 | | | 253.24 | 1.73 | 251.51 |
| | | BELOW FENCE | | | 224.09 | 343.63 | 168.38 | | | 736.1 | 0 | 736.1 |
| | | HATCHERY | 8.81 | | 363.51 | 710.32 | 210.69 | | | 1293.33 | 8.81 | 1284.52 |
| | Adult Male Total | | 10.54 | | 658.77 | 1193.04 | 420.32 | | | 2282.67 | 10.54 | 2272.13 |
| 1991 Total | | | 10.54 | | 658.77 | 2157.82 | 1877.57 | 7.36 | | 4712.06 | 10.54 | 4701.52 |
| 1992 | Adult Fem | BELOW FENCE | | | | 217.44 | 298.3 | 66.3 | | 582.04 | 0 | 582.04 |
| | | HATCHERY | | | | 665.95 | 631.17 | | | 1297.12 | 0 | 1297.12 |
| | Adult Fem Total | | | | | 883.39 | 929.47 | 66.3 | | 1879.16 | 0 | 1879.16 |
| | Adult Male | BELOW FENCE | | | 23.95 | 321.73 | 84.9 | | | 430.58 | 0 | 430.58 |
| | | HATCHERY | | | 77.92 | 1058.64 | 195.43 | | | 1331.99 | 0 | 1331.99 |
| | Adult Male Total | | | | 101.87 | 1380.37 | 280.33 | | | 1762.57 | 0 | 1762.57 |
| | Jack | BROODSTOCK | 28.65 | 85.53 | | | | | | 114.18 | 114.18 | 0 |
| | Jack Total | | 28.65 | 85.53 | | | | | | 114.18 | 114.18 | 0 |
| 1992 Total | | | 28.65 | 85.53 | 101.87 | 2263.76 | 1209.8 | 66.3 | | 3755.91 | 114.18 | 3641.73 |

| Table 4 (cont.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Age | | | | | | | | Chinook | Chinook |
| Rec Yr | Class | Area | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Grand Total | Jacks | Adults |
| 1993 | Adult Fem | BELOW FENCE | | | 15.82 | 15.13 | 202.14 | 26.12 | | 259.21 | 0 | 259.21 |
| | | BROODSTOCK | | | 49.9 | 82.96 | 281.85 | | | 414.71 | 0 | 414.71 |
| | Adult Fem Total | | | | 65.72 | 98.09 | 483.99 | 26.12 | | 673.92 | 0 | 673.92 |
| | Adult Male | ABOVE FENCE | | | 53.24 | 24.84 | 21.46 | | | 99.54 | 0 | 99.54 |
| | | BELOW FENCE | | | 72.61 | | 87.47 | | | 160.08 | 0 | 160.08 |
| | | HATCHERY | | | 312.13 | 145.68 | 125.82 | | | 583.63 | 0 | 583.63 |
| | Adult Male Total | | | | 437.98 | 170.52 | 234.75 | | | 843.25 | 0 | 843.25 |
| | Jack | ABOVE FENCE | | 5.39 | 20.6 | | | | | 25.99 | 5.39 | 20.6 |
| | | BROODSTOCK | | 11.41 | 43.59 | | | | | 55 | 11.41 | 43.59 |
| | Jack Total | | | 16.8 | 64.19 | | | | | 80.99 | 16.8 | 64.19 |
| 1993 Total | | | | 16.8 | 587.89 | 268.61 | 718.74 | 26.12 | | 1598.16 | 16.8 | 1581.36 |
| 1994 | Adult Fem | BELOW FENCE | | | | 155.92 | 158.42 | 30.66 | | 345 | 0 | 345 |
| | | HATCHERY | | | 12.76 | 551.88 | 142.13 | 40.34 | | 747.11 | 0 | 747.11 |
| | Adult Fem Total | | | | 12.76 | 707.8 | 300.55 | 71 | | 1092.11 | 0 | 1092.11 |
| | Adult Male | BELOW FENCE | | | | 104.73 | 95.5 | | | 200.23 | 0 | 200.23 |
| | | HATCHERY | | | 241.49 | 506.78 | 111.21 | | | 859.48 | 0 | 859.48 |
| | Adult Male Total | | | | 241.49 | 611.51 | 206.71 | | | 1059.71 | 0 | 1059.71 |
| | Jack | HATCHERY | 15.47 | | | | | | | 15.47 | 15.47 | 0 |
| | Jack Total | | 15.47 | | | | | | | 15.47 | 15.47 | 0 |
| 1994 Total | | | 15.47 | | 254.25 | 1319.31 | 507.26 | 71 | | 2167.29 | 15.47 | 2151.82 |
| 1995 | Adult Fem | BELOW FENCE | | | | 58.25 | 233.88 | 23.14 | | 315.27 | 0 | 315.27 |
| Rec Yr | Class | Area | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Grand Total | Jacks | Adults |
| | | BROODSTOCK | | | 4 | 292.85 | 224.02 | | | 520.87 | 0 | 520.87 |
| | Adult Fem Total | | | | 4 | 351.1 | 457.9 | 23.14 | | 836.14 | 0 | 836.14 |
| | Adult Male | BELOW FENCE | | | | 101.45 | 42.7 | | | 144.15 | 0 | 144.15 |
| | | BROODSTOCK | | | 98.55 | 347.54 | 92.91 | | | 539 | 0 | 539 |
| | Adult Male Total | | | | 98.55 | 448.99 | 135.61 | | | 683.15 | 0 | 683.15 |
| | Jack | ABOVE FENCE | 7.82 | 5.18 | | | | | | 13 | 13 | 0 |
| | | BROODSTOCK | 10.83 | 7.17 | | | | | | 18 | 18 | 0 |
| | Jack Total | | 18.65 | 12.35 | | | | | | 31 | 31 | 0 |
| 1995 Total | | | 18.65 | 12.35 | 102.55 | 800.09 | 593.51 | 23.14 | | 1550.29 | 31 | 1519.29 |

| Table 4 (cont.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Age | | | | | | | | Chinook | Chinook |
| Rec Yr | Class | Area | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Grand Total | Jacks | Adults |
| 1996 | Adult Fem | ABOVE FENCE | | | 0.04 | 3.32 | 3.07 | | | 6.43 | 0 | 6.43 |
| | | BELOW FENCE | | | | 34.84 | | | | 34.84 | 0 | 34.84 |
| | | BROODSTOCK | | | 0.5 | 41.45 | 38.49 | | | 80.44 | 0 | 80.44 |
| | | HATCHERY | | | 3.77 | 312.91 | 290.7 | | | 607.38 | 0 | 607.38 |
| | Adult Fem Total | | | | 4.31 | 392.52 | 332.26 | | | 729.09 | 0 | 729.09 |
| | Adult Male | ABOVE FENCE | | | 114.7 | 87.58 | 24.38 | | | 226.66 | 0 | 226.66 |
| | | BELOW FENCE | | | 38.45 | 61.61 | | | | 100.06 | 0 | 100.06 |
| | | BROODSTOCK | | | 40.63 | 31.03 | 8.63 | | | 80.29 | 0 | 80.29 |
| | | HATCHERY | | | 386.43 | 295.04 | 82.14 | | | 763.61 | 0 | 763.61 |
| | Adult Male Total | | | | 580.21 | 475.26 | 115.15 | | | 1170.62 | 0 | 1170.62 |
| | Jack | ABOVE FENCE | 8.8 | 18.75 | | | | | | 28.01 | 27.55 | 0.46 |
| | | BELOW FENCE | | 13 | | | | | | 13 | 13 | 0 |
| | | BROODSTOCK | 10.51 | 22.41 | | | | | | 33.46 | 32.92 | 0.54 |
| | Jack Total | | 19.31 | 54.16 | | | | | | 74.47 | 73.47 | 1 |
| 1996 Total | | | 19.31 | 54.16 | 584.52 | 867.78 | 447.41 | | | 1974.18 | 73.47 | 1900.71 |
| 1997 | Adult Fem | ABOVE FENCE | | | 2.6 | 35.27 | 17.84 | 1.62 | | 57.33 | 0 | 57.33 |
| | | BELOW FENCE | | | | 134.76 | 56.84 | | | 191.6 | 0 | 191.6 |
| | | HATCHERY | | | 21.98 | 298.01 | 150.7 | 13.66 | | 484.35 | 0 | 484.35 |
| | Adult Fem Total | | | | 24.58 | 468.04 | 225.38 | 15.28 | | 733.28 | 0 | 733.28 |
| | Adult Male | ABOVE FENCE | | | 95.76 | 46.91 | 6.11 | | | 148.78 | 0 | 148.78 |
| | | BELOW FENCE | | | 49.38 | 138.85 | | | | 188.23 | 0 | 188.23 |
| | | HATCHERY | | | 517.48 | 253.57 | 33.01 | | | 804.06 | 0 | 804.06 |
| | Adult Male Total | | | | 662.62 | 439.33 | 39.12 | | | 1141.07 | 0 | 1141.07 |
| | Jack | ABOVE FENCE | | 6.39 | 4.1 | | | | | 10.49 | 6.39 | 4.1 |
| | | BELOW FENCE | 2 | | | | | | | 2 | 2 | 0 |
| | | HATCHERY | | 19.4 | 12.48 | | | | | 31.88 | 19.4 | 12.48 |
| | Jack Total | | 2 | 25.79 | 16.58 | | | | | 44.37 | 27.79 | 16.58 |
| 1997 Total | | | 2 | 25.79 | 703.78 | 907.37 | 264.5 | 15.28 | | 1918.72 | 27.79 | 1890.93 |
| 1998 | Adult Fem | ABOVE FENCE | | | 1.37 | 51.66 | 14.91 | | | 67.94 | 0 | 67.94 |
| | | BELOW FENCE | | | | 193.66 | 100.18 | 17.7 | | 311.54 | 0 | 311.54 |
| | | BROODSTOCK | | | 2.75 | 103.8 | 29.98 | | | 136.53 | 0 | 136.53 |
| | | HATCHERY | | | 10.24 | 386.7 | 111.69 | | | 508.63 | 0 | 508.63 |
| | Adult Fem Total | | | | 14.36 | 735.82 | 256.76 | 17.7 | | 1024.64 | 0 | 1024.64 |
| | Adult Male | ABOVE FENCE | | 13.52 | 253.67 | 229.74 | 15.07 | | | 512 | 13.52 | 498.48 |
| | | BELOW FENCE | | 77.84 | 260.77 | 203.81 | 73.34 | | | 615.76 | 77.84 | 537.92 |
| | | BROODSTOCK | | 5.51 | 103.57 | 93.79 | 6.16 | | | 209.03 | 5.51 | 203.52 |
| | | HATCHERY | | 20.92 | 392.9 | 355.84 | 23.33 | | | 792.99 | 20.92 | 772.07 |
| | Adult Male Total | | | 117.79 | 1010.91 | 883.18 | 117.9 | | | 2129.78 | 117.79 | 2011.99 |
| | Jack | ABOVE FENCE | | 45.66 | 2.08 | | | | | 47.74 | 45.66 | 2.08 |
| | | HATCHERY | | 72.56 | 3.31 | | | | | 75.87 | 72.56 | 3.31 |
| | Jack Total | | | 118.22 | 5.39 | | | | | 123.61 | 118.22 | 5.39 |
| 1998 Total | | | | 236.01 | 1030.66 | 1619 | 374.66 | 17.7 | | 3278.03 | 236.01 | 3042.02 |

Table 5. Age composition of Quinsam/Campbell Chinook escapement by sex and return year.

**MALES**

Return Year

| | 1984 | | 1985 | | 1986 | | 1987 | | 1988 | | 1989 | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 2 | 101 | 5.7 | 0 | 0.0 | 51 | 4.1 | 3 | 0.3 | 8 | 1.0 | 2 | 0.3 | 5 | 0.9 |
| 3 | 65 | 3.6 | 35 | 5.7 | 209 | 16.9 | 274 | 31.5 | 37 | 4.5 | 256 | 32.3 | 39 | 6.9 |
| 4 | 755 | 42.4 | 434 | 70.7 | 565 | 45.8 | 233 | 26.7 | 660 | 81.3 | 177 | 22.4 | 402 | 71.3 |
| 5 | 785 | 44.1 | 136 | 22.1 | 409 | 33.1 | 321 | 36.9 | 100 | 12.3 | 356 | 44.9 | 110 | 19.5 |
| 6 | 75 | 4.2 | 8 | 1.3 | 1 | 0.1 | 40 | 4.6 | 4 | 0.5 | 1 | 0.1 | 8 | 1.4 |
| 7 | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 3 | 0.4 | 0 | 0.0 | 0 | 0.0 |

| | 1991 | | 1992 | | 1993 | | 1994 | | 1995 | | 1996 | | 1997 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 2 | 0 | 0.0 | | | 6 | 2.1 | 4 | 1.6 | 11 | 3.9 | 52 | 13.1 | 16 | 4.8 |
| 3 | 69 | 17.0 | 24 | 6.0 | 93 | 32.2 | 56 | 23.0 | 53 | 19.0 | 160 | 40.4 | 118 | 35.5 |
| 4 | 223 | 55.1 | 287 | 71.6 | 76 | 26.3 | 149 | 61.1 | 165 | 59.3 | 141 | 35.6 | 164 | 49.2 |
| 5 | 111 | 27.4 | 87 | 21.7 | 110 | 38.0 | 34 | 13.9 | 48 | 17.2 | 42 | 10.6 | 33 | 9.9 |
| 6 | 2 | 0.5 | 3 | 0.7 | 4 | 1.4 | 1 | 0.4 | 1 | 0.6 | 1 | 0.3 | 2 | 0.6 |
| 7 | 0 | 0.0 | | | 0 | | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

**FEMALES**

Return Year

| | 1984 | | 1985 | | 1986 | | 1987 | | 1988 | | 1989 | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 3 | 0 | 0.0 | 3 | 0.5 | 7 | 0.5 | 5 | 0.4 | 0 | 0.0 | 12 | 1.2 | 2 | 0.3 |
| 4 | 289 | 24.0 | 217 | 37.4 | 441 | 32.5 | 193 | 16.6 | 503 | 58.7 | 116 | 11.6 | 491 | 61.0 |
| 5 | 756 | 62.9 | 324 | 55.9 | 898 | 66.3 | 782 | 67.1 | 291 | 33.9 | 867 | 86.6 | 261 | 32.4 |
| 6 | 158 | 13.1 | 35 | 6.0 | 9 | 0.7 | 186 | 15.9 | 62 | 7.2 | 6 | 0.6 | 51 | 6.3 |
| 7 | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 2 | 0.2 | 0 | 0.0 | 0 | 0.0 |

| | 1991 | | 1992 | | 1993 | | 1994 | | 1995 | | 1996 | | 1997 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 3 | 3 | 0.6 | 0 | 0.0 | 12 | 3.1 | 8 | 2.5 | 10 | 2.6 | 7 | 2.3 | 10 | 3.0 |
| 4 | 163 | 34.4 | 232 | 48.3 | 70 | 18.0 | 199 | 62.0 | 173 | 45.0 | 153 | 49.3 | 209 | 62.0 |
| 5 | 299 | 63.1 | 234 | 48.8 | 293 | 75.5 | 93 | 29.0 | 195 | 50.8 | 145 | 46.8 | 115 | 34.1 |
| 6 | 9 | 1.9 | 14 | 2.9 | 13 | 3.4 | 21 | 6.5 | 6 | 1.6 | 5 | 1.6 | 3 | 0.9 |
| 7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

**COMBINED**

Return Year

| | 1984 | | 1985 | | 1986 | | 1987 | | 1988 | | 1989 | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 2 | 101 | 3.4 | 0 | 0.0 | 51 | 2.0 | 3 | 0.2 | 8 | 0.5 | 2 | 0.1 | 5 | 0.4 |
| 3 | 65 | 2.2 | 38 | 3.2 | 216 | 8.3 | 279 | 13.7 | 37 | 2.2 | 268 | 15.0 | 41 | 3.0 |
| 4 | 1044 | 35.0 | 651 | 54.5 | 1006 | 38.8 | 426 | 20.9 | 1163 | 69.6 | 293 | 16.3 | 893 | 65.2 |
| 5 | 1541 | 51.6 | 460 | 38.5 | 1307 | 50.5 | 1103 | 54.1 | 391 | 23.4 | 1223 | 68.2 | 371 | 27.1 |
| 6 | 233 | 7.8 | 43 | 3.6 | 10 | 0.4 | 226 | 11.1 | 66 | 4.0 | 7 | 0.4 | 59 | 4.3 |
| 7 | 0 | 0.0 | 2 | 0.2 | 0 | 0.0 | 0 | 0.0 | 5 | 0.3 | 0 | 0.0 | 0 | 0.0 |

| | 1991 | | 1992 | | 1993 | | 1994 | | 1995 | | 1996 | | 1997 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 2 | 0 | 0.0 | | 0.0 | 6 | 0.9 | 4 | 0.7 | 11 | 1.7 | 52 | 7.4 | 16 | 2.4 |
| 3 | 72 | 8.2 | 24 | 2.7 | 105 | 15.5 | 64 | 11.3 | 63 | 9.5 | 167 | 23.7 | 128 | 19.1 |
| 4 | 386 | 43.9 | 519 | 58.9 | 146 | 21.6 | 348 | 61.6 | 338 | 51.1 | 294 | 41.6 | 373 | 55.7 |
| 5 | 410 | 46.6 | 321 | 36.5 | 403 | 59.5 | 127 | 22.5 | 243 | 36.7 | 187 | 26.5 | 148 | 22.1 |
| 6 | 11 | 1.3 | 17 | 1.9 | 17 | 2.5 | 22 | 3.9 | 7 | 1.0 | 6 | 0.8 | 5 | 0.7 |

Table 6. Comparison of five year mean age-class distributions.

% Age in Escapement

**Campbell River**

| | 1986-1990 (mean) | | | 1991-1996 (mean) | |
|---|---|---|---|---|---|
| Age | male | female | | male | female |
| 2 | 0.05 | 0 | | 0 | 0 |
| 3 | 5.81 | 0.1 | | 8.7 | 0.4 |
| 4 | 40.53 | 18.2 | | 45 | 28.6 |
| 5 | 50.14 | 71.5 | | 44.4 | 64.3 |
| 6 | 0.1 | 10.1 | | 1.9 | 6.7 |
| 7 | 3.37 | 0.1 | | 0 | 0 |
| Total | 100 | 100 | | 100 | 100 |

**Quinsam River**

| | 1986-1990 (mean) | | | 1991-1996 (mean) | |
|---|---|---|---|---|---|
| Age | male | female | | male | female |
| 2 | 0.4 | 0 | | 0.1 | |
| 3 | 15.6 | 0.1 | | 24.4 | 0.7 |
| 4 | 53.1 | 36.9 | | 55.6 | 41.7 |
| 5 | 29.9 | 57.9 | | 19.3 | 54.7 |
| 6 | 0.6 | 5 | | 0.6 | 0.4 |
| 7 | 0.4 | 0.1 | | | 2.5 |
| Total | 100 | 100 | | 100 | 100 |

**Quinsam Hatchery**

| | 1986-1990 (mean) | | | 1991-1996 (mean) | |
|---|---|---|---|---|---|
| Age | male | female | | male | female |
| 1 | 0 | 0 | | 1.7 | 0 |
| 2 | 1.6 | 1 | | 1.8 | 0 |
| 3 | 25 | 52.4 | | 24.3 | 2.1 |
| 4 | 55.7 | 40.8 | | 56.5 | 47.3 |
| 5 | 16.5 | 2.9 | | 15.7 | 49.2 |
| 6 | 0.7 | 2.9 | | | 1.4 |
| 7 | 0.5 | | | | 0 |
| Total | 100 | 100 | | 100 | 100 |

Table 7. Distribution of total fishing mortality for the Quinsam/Campbell chinook stock by fishery and time periods (average values for distributions in calendar years). Analyses completed through the 1999 fishery recoveries and escapement programs.

| | AVERAGES BY 5-YEAR PERIODS | | | |
|---|---|---|---|---|
| *ANNUAL STOCK DISTRIBUTION* | *1980-84* | *1985-89* | *1990-94* | *1995-99* |
| SE ALASKA TROLL | 19.57 | 18.77 | 12.53 | 10.68 |
| SE ALASKA NETS | 6.64 | 9.20 | 5.28 | 4.89 |
| SE ALASKA SPORT | 3.67 | 2.80 | 1.91 | 1.79 |
| NBC (A1-5) TROLL | 11.01 | 5.64 | 8.03 | 3.21 |
| CBC (A6-11) TROLL | 10.67 | 4.13 | 6.12 | 0.94 |
| NBC (A1-5) NETS | 7.95 | 5.68 | 8.95 | 7.61 |
| CBC (A6-10) NETS | 7.34 | 4.88 | 2.82 | 0.24 |
| NCBC (A1-10) SPORT | 4.53 | 3.41 | 8.17 | 8.12 |
| JOHNSTONE ST. NET | 7.33 | 6.85 | 3.30 | 0.87 |
| WCVI TROLL | 0.50 | 0.34 | 0.68 | 0.17 |
| ST. GEORGIA TROLL | 0.96 | 0.13 | 0.71 | 0.00 |
| ST. GEORGIA SPORT | 6.27 | 4.73 | 5.33 | 5.94 |
| OTHER FISHERIES | 0.15 | 0.40 | 0.13 | 1.22 |
| | | | | |
| Total Fishing Mortality | 86.58 | 66.95 | 63.96 | 45.68 |
| | | | | |
| Spawning escapement | 13.42 | 33.05 | 36.04 | 54.32 |
| | | | | |
| TOTAL : | 100.00 | 100.00 | 100.00 | 100.00 |

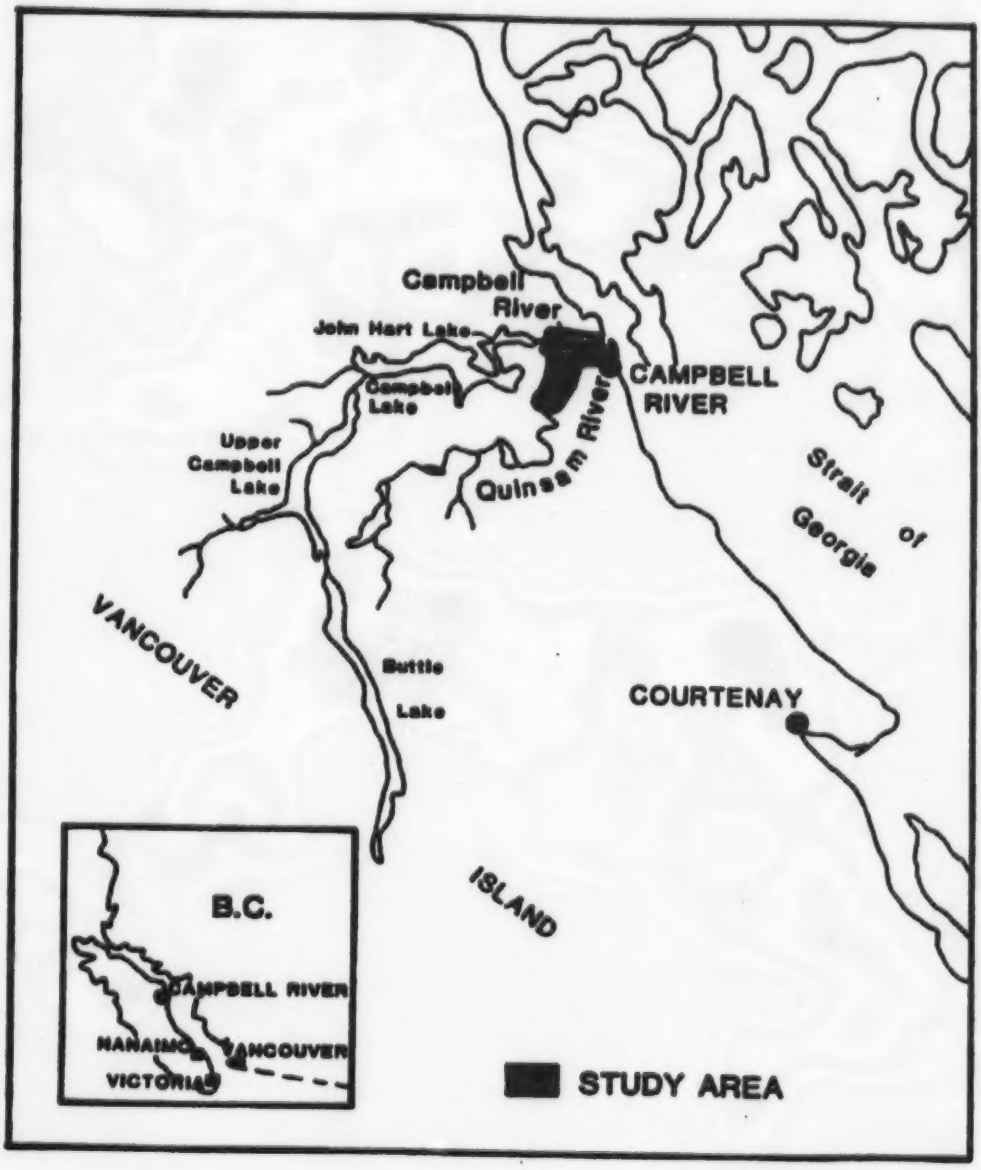


Fig. 1. Campbell/Quinsam watershed and study area.

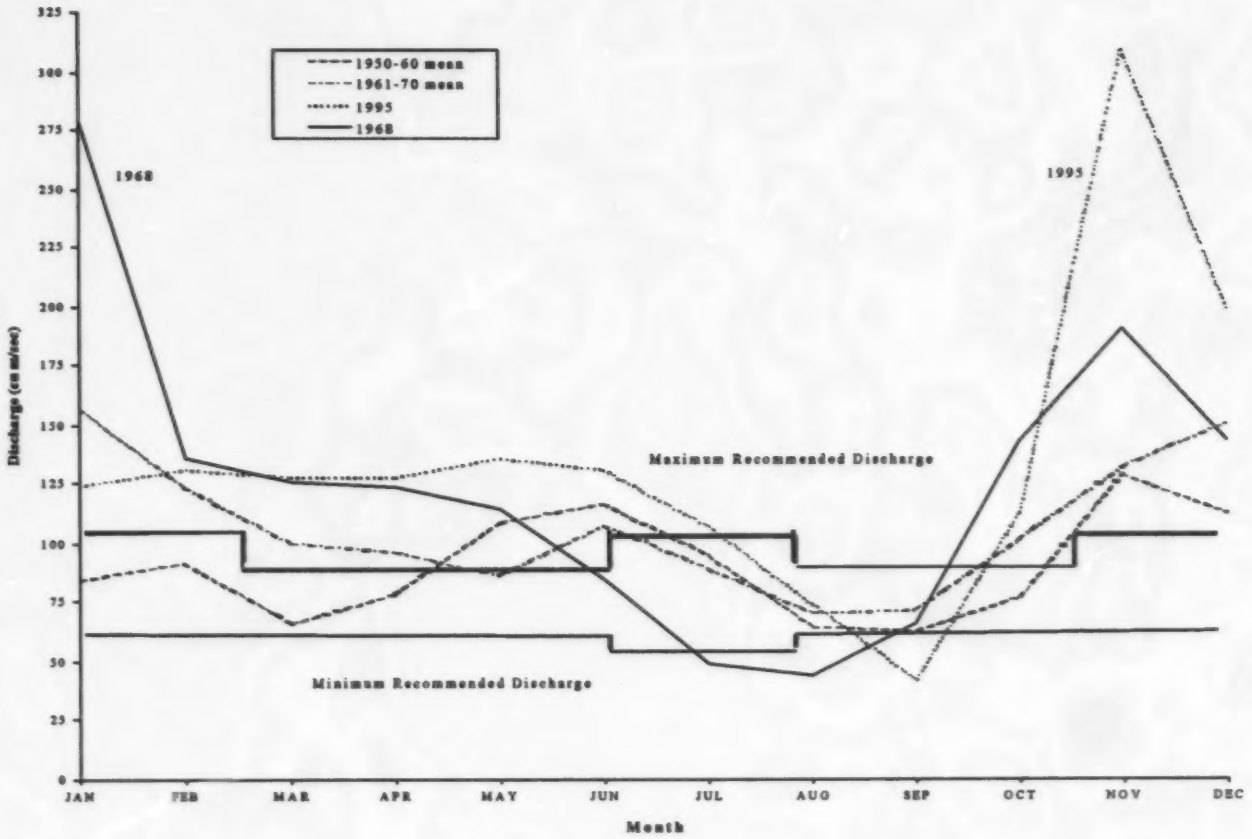


Fig. 2. Historical mean monthly discharge (cu.m/sec) measured at the Island highway bridge, Campbell River.

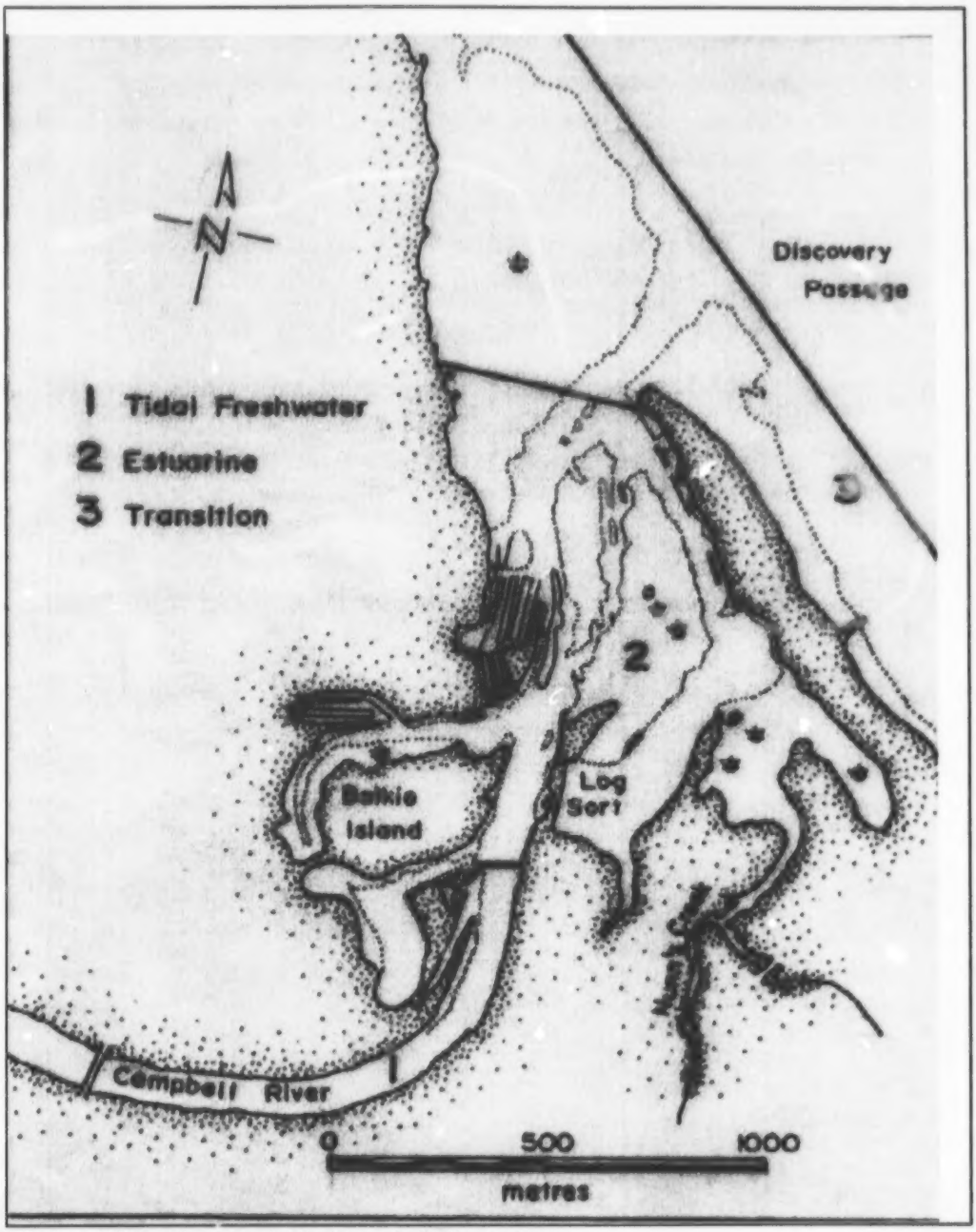


Fig. 3. Industrial development in the Campbell River estuary.
Chinook fry utilization zones for hatchery and naturally-reared juvenile

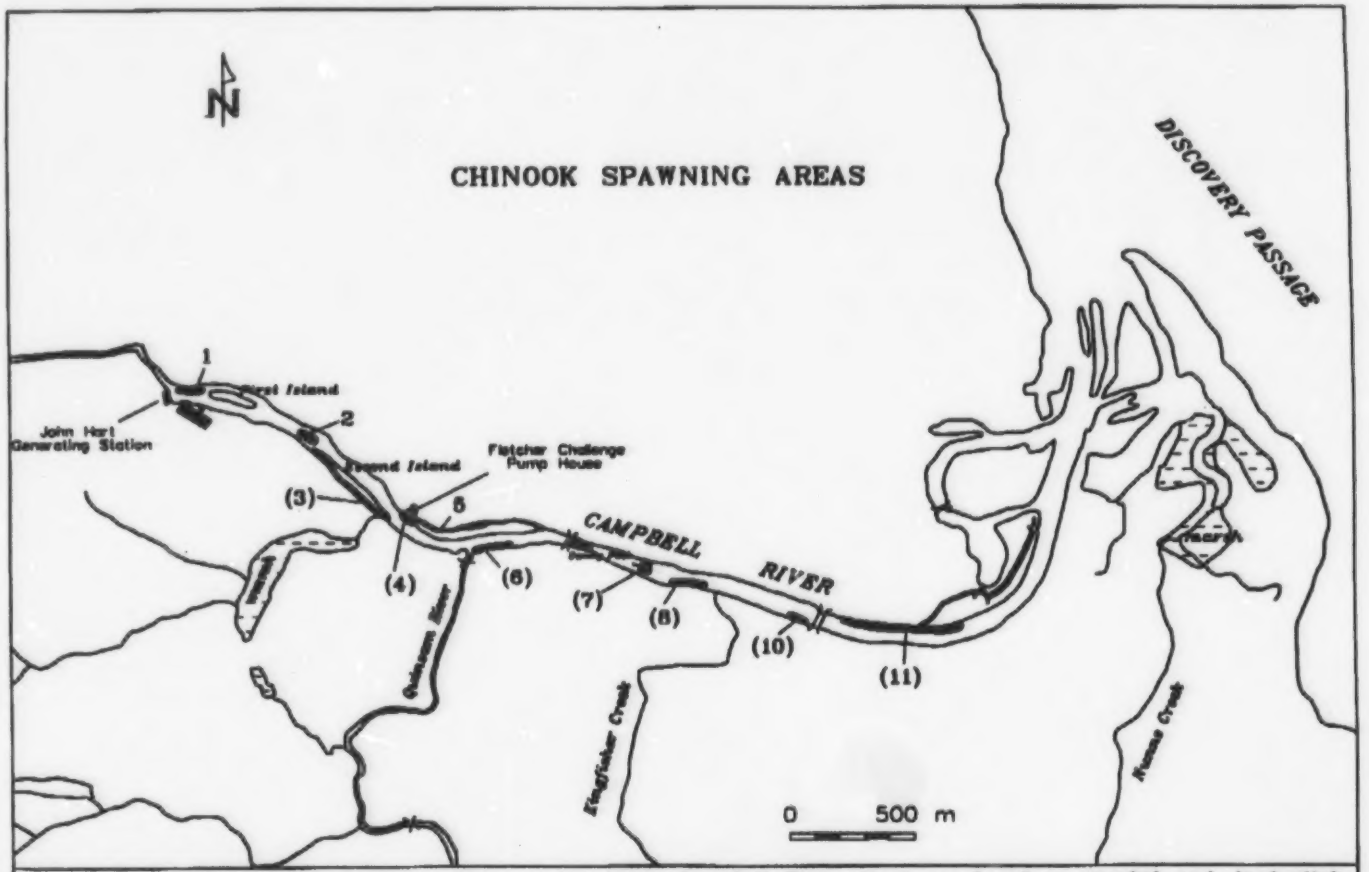


Figure 16. Chinook salmon spawning areas on the Lower Campbell River. Areas are based on snorkel and dead-pitch surveys by Quinsam Hatchery staff. Bracketed area numbers indicate minor spawning areas. Area 5 is a man-made spawning channel. Note: Sporadic spawning may occur in other locations.

Fig. 4. Chinook spawning areas in the Lower Campbell River based on data from Burt and Burns (1995).

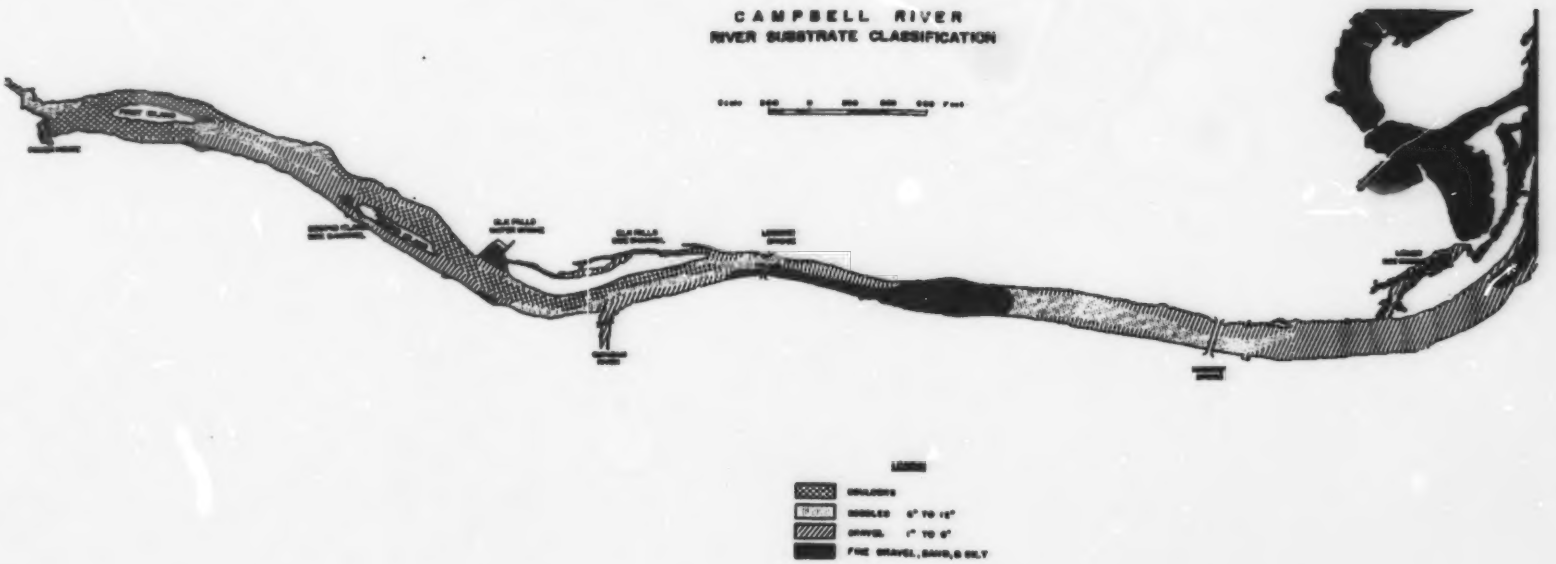


**Figure 23. Distribution of substrate categories in 1973. From Hamilton and Buell (1976).**

Fig. 5. Distribution of substrate categories in 1973 from Hamilton and Buell (1976).

Fig. 6. Campbell River swim survey sections.

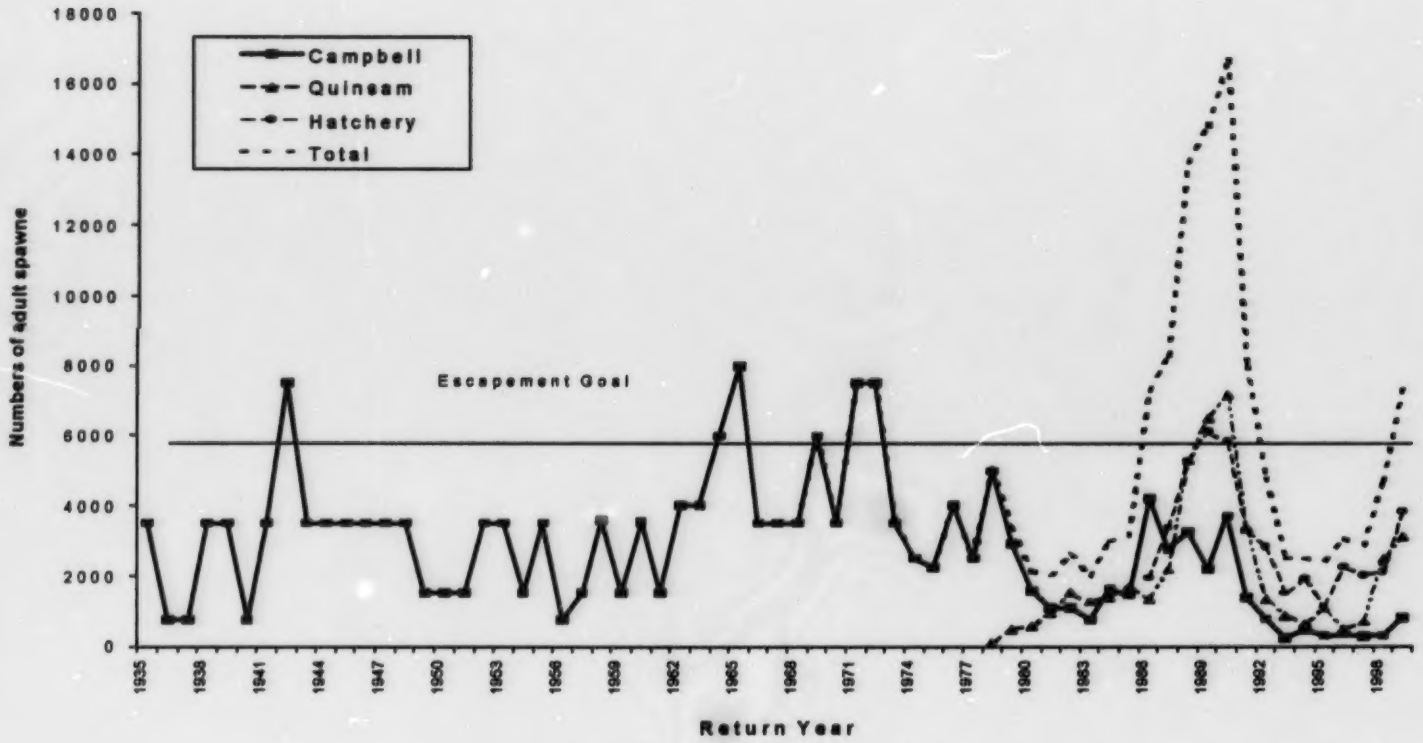


Fig. 7. Chinook adult escapement trends in the Campbell/Quinsam system.

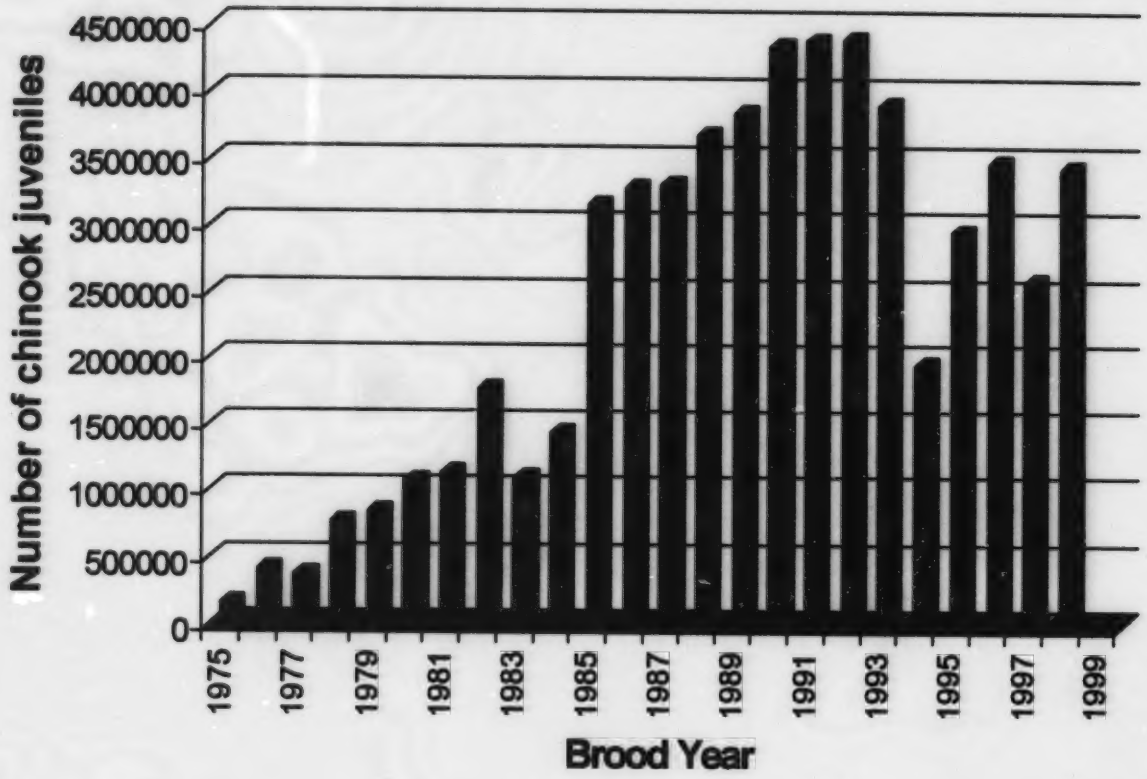


Fig. 8. Quinsam Hatchery juvenile chinook releases by brood year, 1975-97.

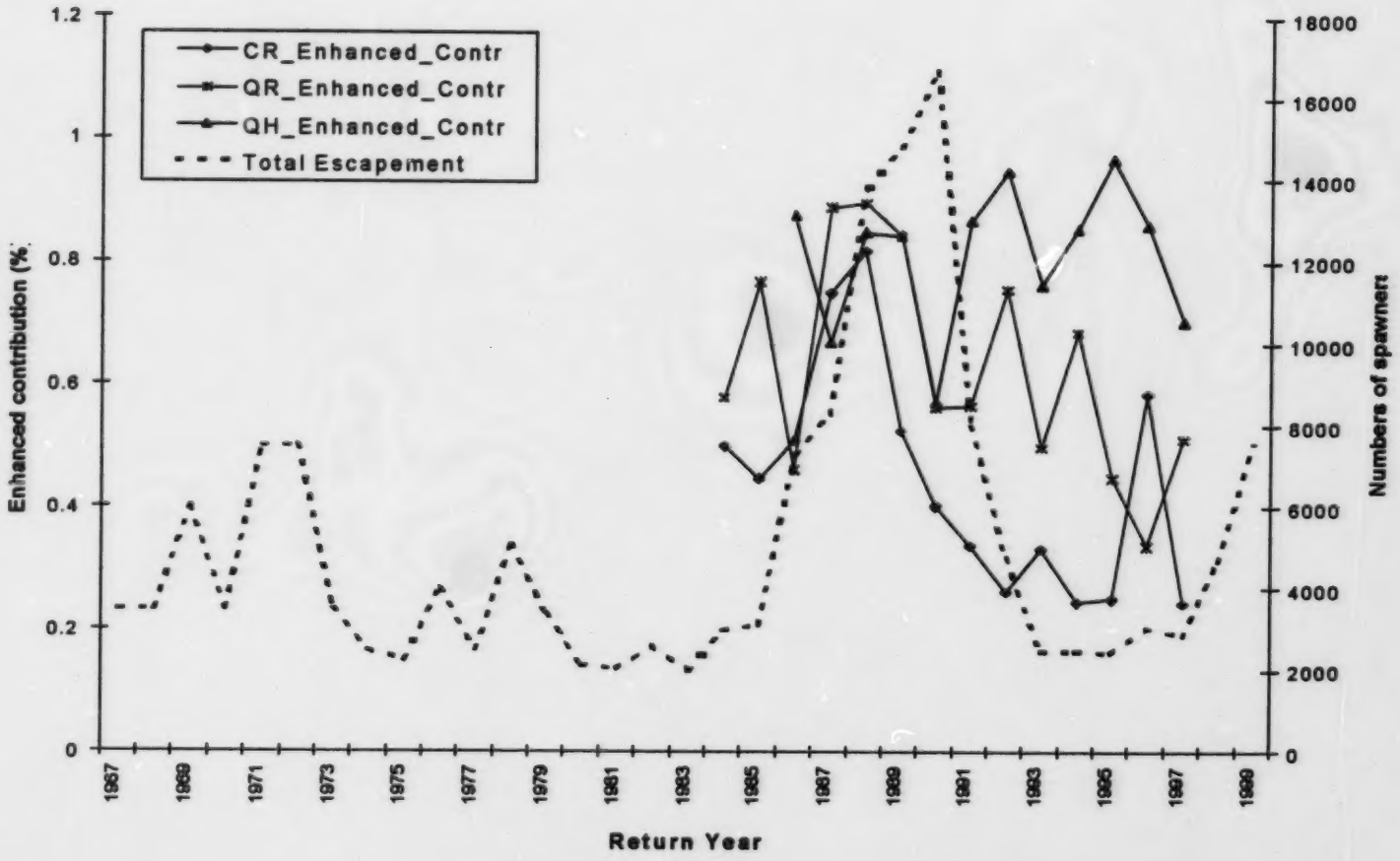


Fig. 9. Enhanced contribution to the Campbell R., Quinsam R. and Quinsam Hatchery escapement by return year.

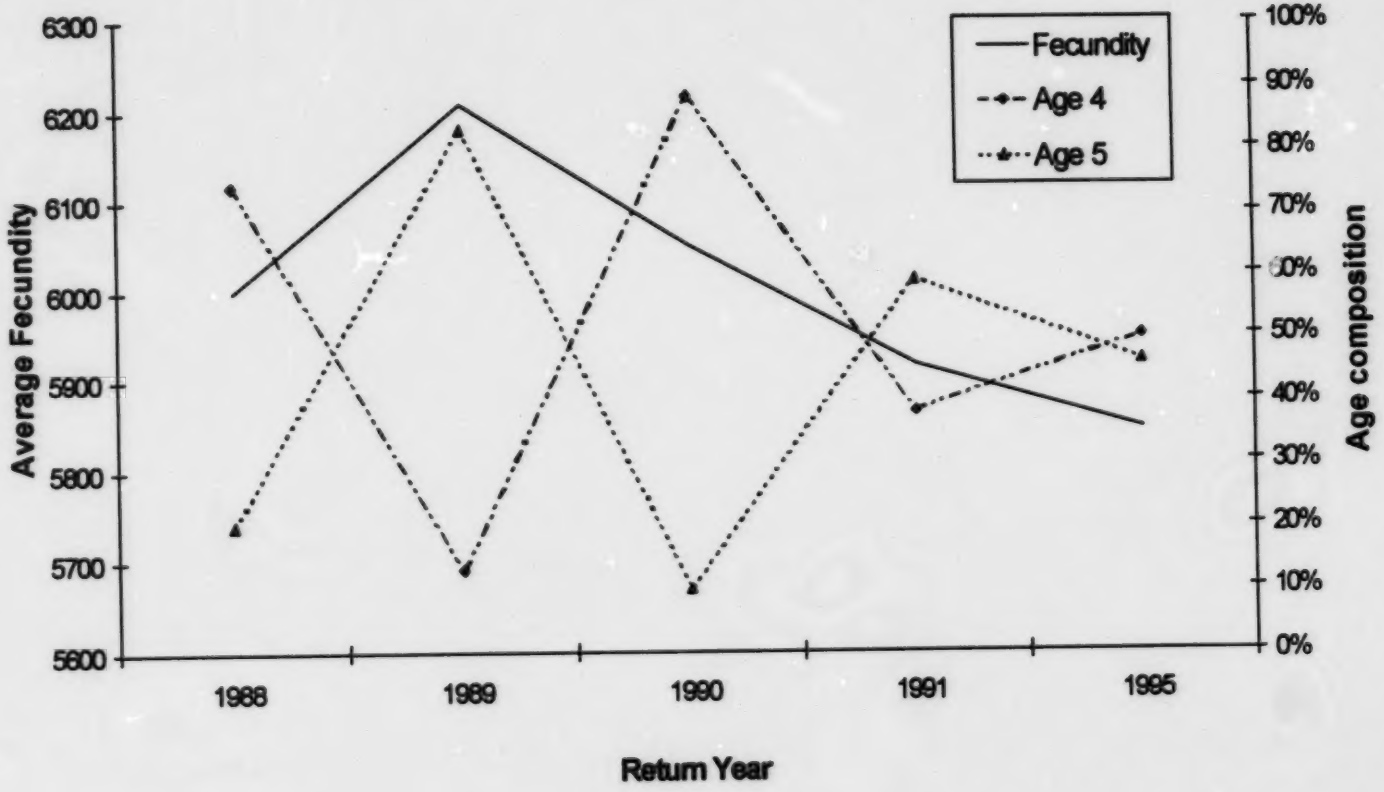


Fig. 10. Fecundity relative to female chinook age for Quinsam Hatchery broodstock.

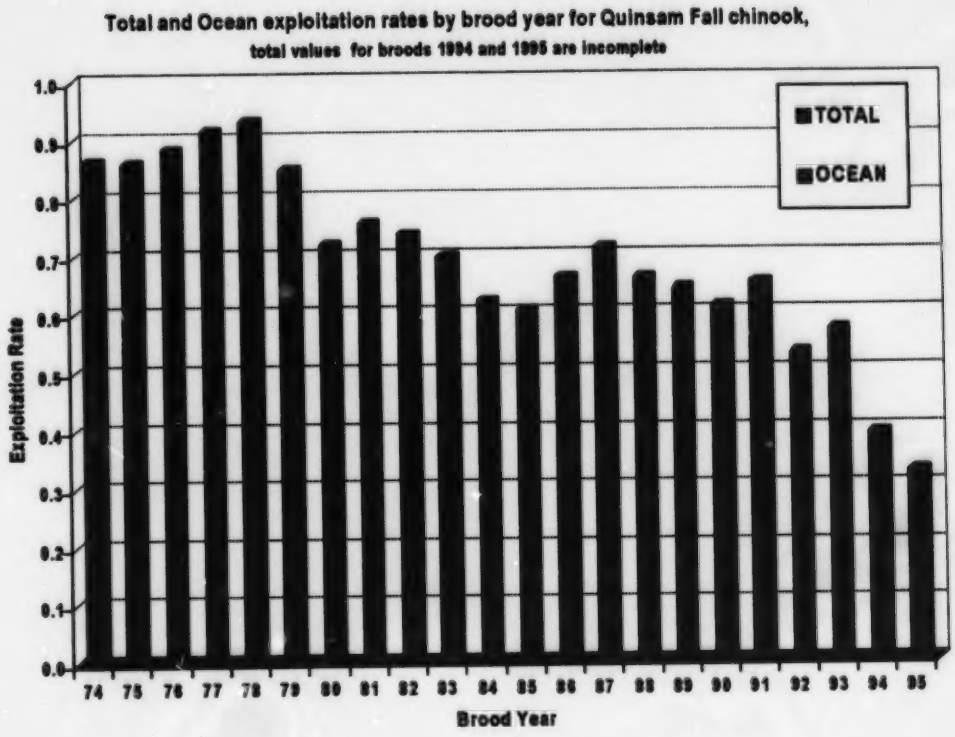


Fig. 11. Ocean and total exploitation rates by brood year for Quinsam fall chinook stock.

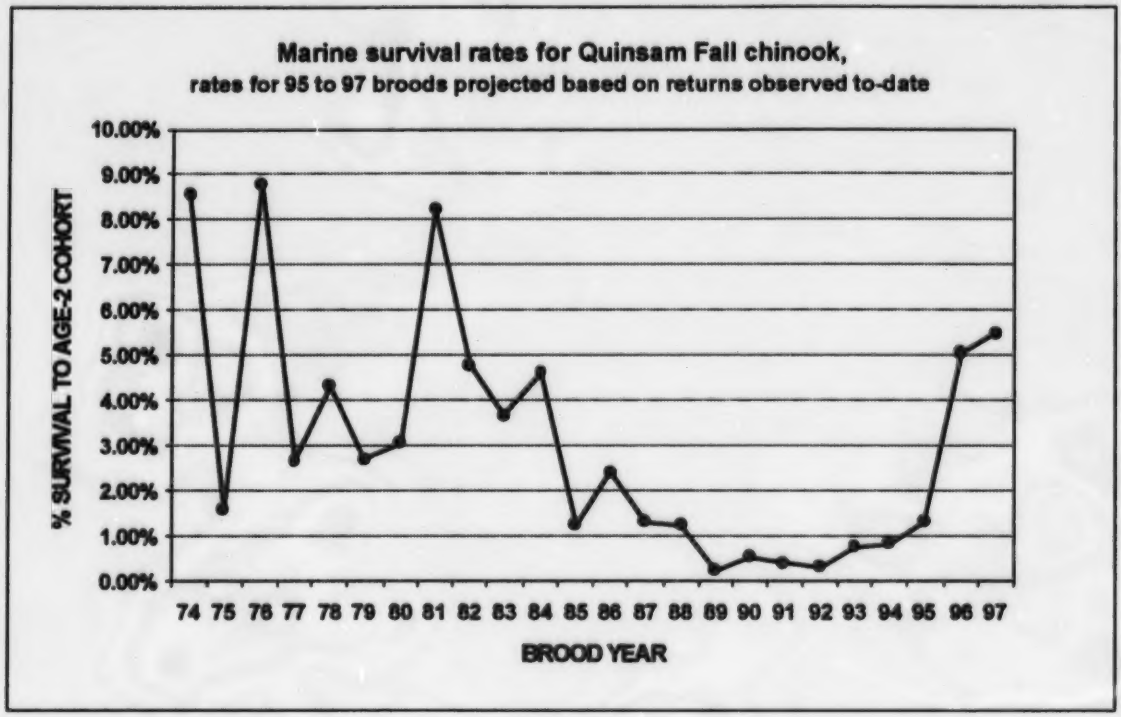


Fig. 12. Marine survival rates for Quinsam fall chinook stock.

Appendix Table 1. Size at age of Quinsam/Campbell chinook escapement by sex and return year.

**MALES**

| | | 1984 | | | 1985 | | | 1986 | | | 1987 | | | 1988 | | | 1989 | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. |
| 2 | 5 | | | 0 | 0 | | 51 | 430 | | 3 | 379 | | 8 | 397 | | 2 | 400 | 35.4 | 3 | 408 | 28.9 |
| 3 | 32 | 589 | | 20 | 590.3 | 46.5 | 209 | 579 | | 272 | 579 | | 35 | 573 | | 246 | 629 | 20.2 | 41 | 615 | 46.4 |
| 4 | 138 | 724 | | 180 | 761.4 | 61.0 | 565 | 725 | | 232 | 758 | | 657 | 745 | | 176 | 770 | 51.3 | 402 | 761 | 56.8 |
| 5 | 60 | 830 | | 80 | 840.1 | 97.8 | 407 | 815 | | 321 | 820 | | 99 | 872 | | 356 | 856 | 58.8 | 110 | 878 | 58.4 |
| 6 | 3 | 865 | | 3 | 899.3 | 141.0 | 1 | 910 | | 38 | 845 | | 4 | 877 | | 1 | 925 | | 8 | 919 | 41.7 |
| 7 | 0 | | | 2 | 990 | 0 | 0 | | | 0 | | | 3 | 835 | | 0 | | | | 0 | |

| | | 1991 | | | 1992 | | | 1993 | | | 1994 | | | 1995 | | | 1996 | | | 1997 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. |
| 2 | 0 | | | 0 | | | 6 | 425 | 89.4 | 4 | 250 | 86.6 | 11 | 325 | 94.9 | 41 | 296 | 119.9 | 15 | 262 | 93.5 |
| 3 | 69 | 650 | 69.5 | 24 | 596 | 41.5 | 93 | 577 | 61.2 | 56 | 617 | 63.8 | 53 | 612 | 66.6 | 66 | 650 | 59.0 | 118 | 607 | 69.7 |
| 4 | 222 | 766 | 53.6 | 287 | 738 | 66.6 | 76 | 705 | 65.4 | 148 | 719 | 56.8 | 165 | 727 | 68.7 | 107 | 774 | 64.4 | 164 | 741 | 67.1 |
| 5 | 110 | 843 | 58.6 | 87 | 831 | 57.5 | 110 | 814 | 57.2 | 34 | 824 | 70.2 | 48 | 818 | 91.1 | 35 | 825 | 71.7 | 33 | 839 | 57.7 |
| 6 | 2 | 925 | 70.7 | 3 | 858 | 76.4 | 4 | 850 | 64.6 | 1 | 775 | | 1 | 925 | | 1 | 875 | | 2 | 850 | 106.1 |
| 7 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |

**FEMALES**

| | | 1984 | | | 1985 | | | 1986 | | | 1987 | | | 1988 | | | 1989 | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. |
| 2 | 0 | | | 0 | 0 | | 0 | | | 0 | | | 0 | 0 | | 0 | 0 | | 0 | | |
| 3 | 0 | | | 3 | 736.6 | 60.8 | 7 | 663 | | 5 | 654 | | 0 | 0 | | 12 | 679 | 54.2 | 2 | 625 | 70.7 |
| 4 | 153 | 762 | | 117 | 767.0 | 40.3 | 441 | 749 | | 192 | 778 | | 502 | 758 | | 116 | 779 | 49.6 | 491 | 771 | 46.3 |
| 5 | 136 | 827 | | 156 | 839.0 | 49.4 | 897 | 826 | | 780 | 832 | | 288 | 849 | | 865 | 849 | 48.3 | 261 | 858 | 50.1 |
| 6 | 13 | 867 | | 24 | 862.8 | 54.1 | 9 | 829 | | 183 | 863 | | 60 | 861 | | 6 | 908 | 60.6 | 51 | 917 | 53.3 |
| 7 | 0 | | | 0 | 0 | | 0 | | | 0 | | | 2 | 883 | | 0 | | | 0 | | |

Appendix Table 1 (cont.)

| | | 1981 | | | 1982 | | | 1983 | | | 1984 | | | 1985 | | | 1986 | | | 1987 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. |
| 2 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| 3 | 3 | 675 | 100.0 | 0 | | | 12 | 663 | 37.7 | 8 | 700 | 65.5 | 10 | 685 | 90.7 | 6 | 675 | 44.7 | 10 | 660 | 58.0 |
| 4 | 163 | 776 | 44.1 | 231 | 748 | 44.6 | 70 | 728 | 44.9 | 198 | 741 | 46.7 | 173 | 760 | 50.0 | 128 | 785 | 54.1 | 209 | 748 | 46.2 |
| 5 | 299 | 839 | 49.5 | 234 | 815 | 50.5 | 293 | 802 | 46.7 | 94 | 816 | 52.9 | 195 | 806 | 53.0 | 121 | 818 | 49.0 | 116 | 829 | 46.9 |
| 6 | 9 | 864 | 48.6 | 14 | 879 | 30.8 | 12 | 825 | 42.6 | 20 | 868 | 46.7 | 6 | 850 | 68.9 | 5 | 865 | 41.8 | 3 | 825 | 0.0 |
| 7 | 0 | | | 0 | | | | | | 0 | | | 0 | | | 0 | | | | | |

COMBINED

| | | 1984 | | | 1985 | | | 1986 | | | 1987 | | | 1988 | | | 1989 | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. |
| 2 | 5 | | | 0 | | | 51 | 430 | | 3 | 379 | | 8 | 397 | | 2 | 400 | 35.4 | 3 | 408 | 28.9 |
| 3 | 32 | 589 | | 23 | 609.6 | 66.46 | 216 | 621 | | 277 | 609 | | 35 | 573 | | 256 | 631 | 55.0 | 43 | 616 | 46.6 |
| 4 | 291 | 743 | | 297 | 760.5 | 56.73 | 1006 | 737 | | 424 | 768 | | 1159 | 752 | | 292 | 774 | 50.8 | 893 | 766 | 51.6 |
| 5 | 196 | 829 | | 236 | 833.9 | 52.85 | 1304 | 820 | | 1101 | 826 | | 387 | 860 | | 1221 | 851 | 51.7 | 371 | 864 | 53.5 |
| 6 | 16 | 866 | | 27 | 862 | 70.15 | 10 | 869 | | 221 | 854 | | 64 | 867 | | 12 | 911 | 55.6 | 59 | 917 | 51.5 |
| 7 | 0 | | | 2 | 975 | 0 | 0 | | | 0 | | | 5 | 867 | | 0 | | | 0 | | |

| | | 1981 | | | 1982 | | | 1983 | | | 1984 | | | 1985 | | | 1986 | | | 1987 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Age | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. |
| 2 | 0 | | | 0 | | | 6 | 425 | 89.4 | 4 | 250 | 86.6 | 11 | 325 | 94.9 | 41 | 296 | 120.0 | 15 | 262 | 93.5 |
| 3 | 72 | 651 | 70.2 | 24 | 596 | 41.5 | 105 | 587 | 64.9 | 64 | 627 | 69.3 | 63 | 623 | 75.1 | 72 | 652 | 58.1 | 128 | 611 | 70.1 |
| 4 | 385 | 771 | 50.0 | 518 | 742 | 58.0 | 146 | 716 | 57.5 | 346 | 732 | 52.4 | 338 | 774 | 62.0 | 235 | 780 | 59.2 | 373 | 745 | 56.4 |
| 5 | 409 | 840 | 52.0 | 321 | 819 | 52.9 | 403 | 805 | 51.4 | 128 | 818 | 57.8 | 243 | 808 | 62.4 | 156 | 819 | 54.8 | 149 | 831 | 49.4 |
| 6 | 11 | 875 | 54.8 | 17 | 875 | 39.6 | 16 | 831 | 47.9 | 21 | 863 | 49.8 | 7 | 861 | 69.0 | 6 | 867 | 37.6 | 5 | 835 | 54.8 |
| 7 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |

Appendix Table 2. Chinook spawner distribution based on swim survey data.

**Area # 1 Canyon & outflow of canyon**

| Date | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aug 3rd wk | | | | | | | | | | | | | 2 | | | 1 | | 5 | | | | | | | 1 |
| Aug 4th wk | | | | | 28 | | | | | | | | | | | 80 | 50 | | | 2 | | | | | |
| Sep 1st wk | 50 | | 15 | | 5 | | | | | | | | | | | | | | | | | | | | 5 |
| Sep 2nd wk | 60 | 1 | 8 | 24 | | 2 | 1 | | 10 | | 1 | | | | | | | | | | | | | | |
| Sep 3rd wk | | 60 | 20 | 50 | 40 | | | 20 | 30 | 1 | | 30 | | | | | | | 50 | | | 50 | | 20 | |
| Sep 4th wk | | 75 | 20 | | 30 | | | 20 | 50 | 1 | | | | | | | | 100 | 100 | | | | | 50 | |
| Oct 1st wk | 100 | 150 | 55 | 125 | 32 | 7 | 1 | 20 | 100 | 2 | 9 | 1 | | | | | | 200 | | | | 20 | | 10 | |
| Oct 2nd wk | 130 | 70 | 151 | 135 | 56 | 5 | 2 | 30 | 50 | 6 | | 10 | | | | | | 5 | | | | | | | |
| Oct 3rd wk | 50 | 60 | 45 | | 20 | 11 | | 3 | 2 | | | | | | | | | | 20 | | | | | | |
| Oct 4th wk | 12 | 50 | 4 | | 8 | 2 | | | 1 | | | | | | | | | | | | | | | 5 | |
| Nov 1st wk | | | 2 | | | | | | | | | | | | | | | | | | | | | 1 | |

Appendix Table 2 (cont.)

**Area # 2 Upper Island & Pool**

| Date | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aug 3rd wk | | | | | | | | | | 5 | 1 | 50 | | | 5 | 2 | | 2 | | | 12 | 5 | | 70 | 1 |
| Aug 4th wk | | 25 | | | 2 | | | | 3 | 2 | | 40 | 1 | 3 | 10 | 5 | 7 | 25 | | 1 | 5 | 30 | 15 | 55 | 10 |
| Sep 1st wk | 12 | | 3 | | | | | | | | 1 | 70 | 1 | | | 200 | | | | 1 | 20 | 100 | 100 | 120 | 10 |
| Sep 2nd wk | 60 | 60 | 62 | 52 | | | 7 | | 2 | 3 | 2 | 50 | | | | 80 | | 50 | 10 | 1 | 125 | 100 | 140 | 180 | 30 |
| Sep 3rd wk | | 6 | 74 | | 10 | | | 3 | | 5 | 1 | 55 | | | | | | | | 10 | | 80 | 75 | 350 | 10 |
| Sep 4th wk | | 80 | 27 | 29 | | | | 5 | 1 | 10 | 4 | 75 | | | 5 | | | 200 | | | 32 | | 100 | 180 | 20 |
| Oct 1st wk | | 66 | 25 | 156 | 1 | | 2 | 22 | 10 | 10 | 3 | 60 | | | 60 | | | 100 | | 5 | 120 | 200 | | 250 | 30 |
| Oct 2nd wk | 60 | 240 | 78 | | 4 | 3 | 5 | 45 | 10 | 20 | | 140 | | | | | | 20 | | | | 125 | | | 50 |
| Oct 3rd wk | 200 | 175 | 228 | 311 | 35 | 4 | 1 | 20 | 2 | 27 | | | | | | | | | 10 | 200 | 35 | 40 | | | 50 |
| Oct 4th wk | 10 | 183 | 500 | 270 | | | 1 | | 75 | | 31 | | | | | | 29 | | | | | | | 10 | 10 |
| Nov 1st wk | | 40 | 8 | | 41 | 9 | 1 | | | 12 | | 5 | 5 | | | | | | | | | | | 1 | |
| Nov 2nd wk | | | | 54 | 18 | | | | | | | | | | | | | | | | | | | | |

Appendix Table 2 (cont.)

**Area # 3 Lower Island Pool & side channel**

| Date | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aug 3rd wk | | | | | | | | 4 | 1 | | | 4 | | 6 | 5 | 15 | 7 | 8 | | 1 | 12 | 12 | | 13 | 15 |
| Aug 4th wk | | 20 | 4 | | | | 1 | 7 | 2 | 5 | | 16 | | 10 | | 50 | | 20 | | | 2 | 20 | 15 | 30 | 3 |
| Sep 1st wk | | | 8 | | | | 3 | 9 | | | 1 | 20 | | 5 | | | | | | 5 | 70 | 50 | 50 | 15 | 40 |
| Sep 2nd wk | 60 | 18 | 44 | | | 1 | 1 | 3 | | | 1 | 50 | | | 10 | 20 | | 100 | 30 | 34 | 100 | 120 | 25 | 50 | 110 |
| Sep 3rd wk | | | 16 | 28 | 30 | | 1 | 20 | 1 | 5 | 1 | 40 | | 6 | | | | | 100 | | | 70 | 15 | 80 | 50 |
| Sep 4th wk | | 5 | 20 | 124 | 10 | 4 | 14 | 18 | 10 | 10 | | 20 | | 1 | 20 | | | 50 | 50 | | 85 | | 35 | 95 | 350 |
| Oct 1st wk | 15 | 46 | 50 | 202 | 10 | 2 | 20 | 26 | 25 | 20 | 9 | 40 | | | 310 | | | 200 | | 5 | 55 | 125 | | 160 | |
| Oct 2nd wk | 230 | 480 | 84 | 345 | 45 | 40 | 50 | 125 | 57 | 25 | 6 | | | | | 70 | | 60 | | | | 30 | | 5 | 70 |
| Oct 3rd wk | 110 | 125 | 91 | | 40 | | 98 | 20 | 30 | 24 | 15 | 130 | | | | | | | 5 | 120 | 32 | 30 | 100 | 105 | 180 |
| Oct 4th wk | 200 | 560 | | 603 | | | 140 | | 100 | | 78 | | | 500 | | | 50 | | | | | | | 103 | |
| Nov 1st wk | | 1100 | | | 250 | 90 | 33 | | | | | | 60 | | | | | | | | | | | 5 | 100 |
| Nov 2nd wk | | | | 20 | 15 | | | | | 45 | | 20 | | | | | | | | | | | | 3 | |

Appendix Table 2 (cont.)

**Area # 4 Below Lower island to Quinsam inflow**

| Date | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aug 3rd wk | | | | | | | | 2 | 16 | | | 15 | | | | | | 3 | | 6 | | 6 | 12 | 5 | 10 |
| Aug 4th wk | | | 1 | | | | 1 | 7 | 8 | 6 | | 10 | 20 | 18 | 10 | 400 | | | | | 10 | 5 | 10 | 6 | |
| Sep 1st wk | 6 | 20 | 2 | | | | 2 | 1 | 55 | 1 | | 10 | 2 | 10 | | | | | | 5 | 30 | 30 | 50 | 10 | 20 |
| Sep 2nd wk | | 3 | | 14 | | 1 | 3 | | 1 | 30 | 1 | | | | 40 | 70 | | 10 | 30 | | 20 | 250 | 20 | 50 | 10 |
| Sep 3rd wk | | 1 | 5 | | 75 | 1 | | 5 | 1 | 5 | 2 | 15 | | | | | | | 50 | 100 | | 120 | 20 | 50 | 60 |
| Sep 4th wk | | 52 | 15 | 20 | 2 | | 7 | 8 | 70 | 56 | | 5 | | 20 | 200 | | | 50 | 200 | 100 | 50 | | | 100 | 100 |
| Oct 1st wk | 60 | 26 | 33 | 43 | | 5 | 15 | 30 | 10 | 15 | 4 | 25 | | | 500 | | | 40 | 15 | 300 | 150 | 100 | 10 | 350 | |
| Oct 2nd wk | 25 | 190 | 75 | 334 | 20 | 13 | 46 | 16 | 75 | 20 | 6 | 150 | | | | | | 5 | | | 97 | 20 | | | 125 |
| Oct 3rd wk | 10 | 320 | 153 | | 100 | 45 | 76 | 75 | 100 | 33 | 70 | | | | | 125 | | | | 150 | | | 15 | 20 | 40 |
| Oct 4th wk | 30 | 867 | 440 | 885 | | | 200 | | 40 | | 96 | | | 380 | | | 30 | | 50 | | | 400 | | 40 | |
| Nov 1st wk | | 400 | 180 | | 150 | 235 | 13 | | | 55 | | | 120 | | | | | | | | | | | | 10 |
| Nov 2nd wk | | | | 72 | 18 | | | | | | | 20 | | | | | | | | | | | | | |

Appendix Table 2 (cont.)

**Area # 5 Quinsam confluence to Highway bridge**

| Date | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aug 3rd wk | | | | | | | 2 | 50 | 45 | | 5 | 8 | 1 | 315 | | 100 | 600 | 100 | 100 | 130 | 10 | 50 | 65 | 120 | 95 |
| Aug 4th wk | | 2 | | | 6 | | | 50 | 200 | 70 | 200 | 400 | 620 | 610 | 250 | 450 | 100 | 350 | 100 | 210 | 550 | 400 | 228 | 200 | 186 |
| Sep 1st wk | 32 | | 2 | | 4 | 1 | 40 | 153 | 220 | 15 | 304 | 356 | 51 | 502 | | 250 | | | 100 | 220 | 775 | 900 | 250 | 305 | 630 |
| Sep 2nd wk | 300 | 50 | 41 | | | 25 | 42 | 150 | 810 | 75 | 200 | 250 | 61 | | | 2400 | | 550 | 400 | 300 | 1030 | 950 | 600 | 260 | 515 |
| Sep 3rd wk | | 55 | 35 | 90 | 37 | 11 | 118 | 239 | 605 | 240 | 609 | 440 | | 620 | 1240 | | | | 400 | 425 | | 530 | 400 | 450 | 475 |
| Sep 4th wk | | 249 | 30 | 336 | 414 | 4 | 104 | 805 | 1015 | 362 | 426 | 350 | | 900 | 6400 | | | 550 | 610 | 600 | 360 | | 570 | 460 | 1575 |
| Oct 1st wk | 150 | | 156 | 773 | 80 | 160 | 230 | 570 | 1300 | 510 | 278 | 680 | | | 2500 | | | 1210 | | 350 | 1175 | 600 | | 920 | |
| Oct 2nd wk | 70 | 710 | 133 | | 172 | 25 | 300 | 670 | 1060 | 100 | 1230 | 800 | | | | | 3250 | 1250 | | 1300 | | 600 | | 1100 | 2850 |
| Oct 3rd wk | 20 | 530 | 389 | 925 | 150 | | 226 | 260 | 2400 | 325 | 225 | | | | | 1050 | | | 1450 | | 120 | 600 | 35 | | 2150 |
| Oct 4th wk | 100 | 655 | 319 | 1304 | | | 210 | | 290 | | | | | 1750 | | | 760 | | 110 | | | | | 30 | |
| Nov 1st wk | | 244 | 133 | | 123 | 45 | 14 | | | 22 | | | 320 | | | | | | | | | | | | 10 |
| Nov 2nd wk | | | | 86 | 13 | | | | | | | 10 | | | | | | | | | | | | 3 | |

Appendix A. Summary of Campbell River habitat restoration projects, 1982 – present.

- **Introduction:**

Only 6.5 km long from the impassable Elk Falls to the estuary, the mainstem of the lower Campbell River has always had a limited area available for anadromous salmon rearing and spawning. The Campbell River has historically been important Chinook salmon spawning habitat. The impoundment of the system, since 1947, has effected natural river dynamics, with minimal opportunity for gravel, organics and food items to be added to the system. Before dam construction the Campbell River was 65km long draining a watershed of nearly 1500km$^2$. The high kinetic energy of the lower river restricts rearing areas for juveniles. Since the construction of John Hart dam natural gravel recruitment to the Campbell River has virtually ceased. Over the past 50 years, periodic high flow events have resulted in the remaining gravel bed being flushed downstream through the estuary, leaving the river armoured with large cobbles and boulders, material unsuitable for salmonid spawning. The upper streambank, or riparian zone, with trees, shrubs and other vegetation is extremely important as a source of food items, cover, and protection from high temperature. The addition of logs and stumps to the system increases the food production and cover available to salmon.

The habitat restoration projects on the Campbell River system are the result of community initiative to deal with issues raised in response to the pressures on fish stocks. In 1994, in response to industry's request to dredge in the estuary to allow more access to the area by tugs and barges, a commission was formed of all stakeholders to address all concerns and determine a vision for the estuary. The Campbell River Estuary Management Plan (CREMP) was developed and implemented. The Campbell River Interim Flow Management Strategy (CRIFMS) was developed in response to the high flow events of 1995, which caused a loss of created spawning habitat (a community initiated and funded-$210,000, spawning channel construction). A schedule outlining instream fisheries flows and constraints was developed by the Vancouver Island Hydro/Fisheries Technical Committee to provide a more natural hydrograph to the system and set criteria for ramping rates and a system of consultation for any unscheduled changes to flows. Through the implementation of these programs, systems are in place to monitor, assess and enhance habitat, as well as providing a protocol for activities relating to salmon habitat on the system. Local groups, all levels of government, industry and other stakeholders have had an opportunity to partner the various projects. The programs on the Campbell have been based on a comprehensive approach to habitat restoration. All stages of salmonid life history, including adult spawning and juvenile rearing, both within the river and estuary have been supported with restoration projects.

Enhancement opportunities were identified to address the limiting factors to salmonid production on the Campbell. A number of these habitat improvement strategies were identified by the Assessment of Salmonid Habitat in the Lower Campbell River (Burt & Burns, 1995). The Lower Campbell River was determined to have a shortfall of 15,000 to 20,000 m$^2$ of the Chinook spawning habitat required to meet target escapements, as set in the CRIFMS (2000 pairs). Gravel nourishment and placement, in side channel developments as well as mainstem spawning platforms, were considered a priority. Additional projects identified as key elements in improving salmonid production of the Campbell include; twinning of Elk Falls to provide additional spawning and rearing, mainstem river complexing, lower river rearing channels, estuary habitat and the canyon reach restoration. The Campbell River Hydro/Fisheries Advisory Committee (May 1997) recognized that the development of any new spawning areas must be evaluated in terms of other species and life stage requirements, recreational use of the river, and aesthetics, particularly in relation to incorporating projects into parks, both provincial and municipal.

- **ELK FALLS SPAWNING CHANNEL:**

**1992**

The Elk Falls Channel was constructed in 1992 immediately downstream of the Elk Falls Pulp Mill pumphouse. The channel consists of a spawning area of 1176m$^2$ (147m X 8m), with a settling pool immediately downstream of the intake structure and a natural rearing area for juveniles from below the lower fence of the channel outlet to the entrance to the mainstem Campbell. The gravel, at construction, was deposited to a depth of 30cm consisting of a range from 2.5cm to 15cm with most being 5cm. In 1995 a further 30cm of gravel was added due to concerns the initial deposition was insufficient for chinook spawning, bringing the total gravel placement to 60cm. Shore box cribbing (wooden) at the lower end of the constructed channel allows the placement of a fence to prevent out migration of adult chinook in the channel as well as inundation by chum which may result in over-spawning and decreased chinook survivals. As well there is a barrier preventing in and out migration through the intake structure on the channel entrance. The spawning channel has a controlled flow system with a valve on the intake structure to regulate flows for spawning and rearing. This valve greatly simplifies the control of flows over the initial stop log system.

During the fall of 1992 the channel was stocked with broodstock chinook captured from the Quinsam River (157 females and 162 males), then planted with eyed eggs (~231,000) from Quinsam Hatchery incubation. In 1994 there was a further stocking of 102 female and 96 male chinook to the channel. Following a number of years of stocking the channel with chinook broodstock captured from the Quinsam River it is hoped that it will only be necessary to supplement the natural return.

- **ELK FALLS TWIN SIDE CHANNEL PROJECT**

**1998**

Elk Falls Twin Side Channel is on the north bank of the Campbell River, adjacent to Fletcher Challenge's Elk Falls water pump station, and approximately 1 km downstream from the John Hart Generating station. Water diverted from the Elk Falls Chinook Spawning Channel (constructed 1992) twins that channel, rejoining it 140 metres before the combined flow re-enters the Campbell.

| **Cost Summary:** | **Total** | **$135,000** |
|---|---|---|
| | Tyee | $ 85,000 |
| | DFO (constr. costs) | $ 35,000 |
| | DFO (in house costs) | $ 15,000 |

**Project Description:**

This system of side channels with a controlled intake allows protection from potential flooding flows in the main river, as well as providing areas of prey production and accumulation 515 metres of channel were excavated between July 23rd and August 27th 1998. The channel intake comes off a pool in the Elk Falls Side Channel 20 m downstream from three 1.8m x 1.2m box culverts providing flow from the Campbell into the two side channels. The Elk Falls Twin Channel lies on both Fletcher Challenge land and within Elk Falls Provincial Park.

Elk Falls Twin varies in width from 3.5 to 8 metres and provides 200 m by 6 m of spawning habitat. Some spawning gravel was imported to mix with the native gravel uncovered during excavation and a minimum depth of 0.6 to 1 metres was placed in the spawning sections.

200 metres downstream from the intake an island was created by excavating a 110 metre long watercourse off the main "Twin" channel and loaded with large woody debris (LWD) for fry rearing. 20m upstream from the new channel exit, water was diverted through a 0.6m steel box culvert into what was previously, a 100m long x 1m wide, ephemeral watercourse.

The channel bed has a 0.3% grade. Invert control for Elk Fall Twin is set to the same elevation as the invert control in Elk Falls Side Channel. The invert control weir was built from rock with a 20:1 downstream slope, designed for stability and fish passage.

- **SECOND ISLAND SPAWNING CHANNEL:**

**1985, 1995, 1996**

**Cost Summary:**

| *Aug. '95* | | *Aug. '96* | |
|---|---|---|---|
| Tyee | $120,000 | B.C. Hydro (constr. costs) | $160,000 |
| D.F.O. (constr. costs) | $50,000 | B.C. Hydro (hydraulic study) | $50,000 |
| D.F.O. (design/supervision) | $40,000 | D.F.O. (design/supervision) | $20,000 |
| **Total** | **$210,000** | **Total** | **$230,000** |

Unlike the 1985 effort, built by DFO alone, the 1995 initiative was a co-operative effort between DFO and the Campbell River Gravel Committee, a local community group. DFO provided the engineering design, biological support, and construction management. To reduce the threat of washout from flood flows, the original 1985 design was modified by raising the spawning bed elevation in an attempt to limit the amount of water entering the channel without constructing an intake structure. Unfortunately, BC Hydro released 20,000 cfs down the Campbell River thus flushing out 45% of the gravel from the channel to the river.

The Hydro/Fisheries Advisory Committee representing all stakeholders was formed to oversee rehabilitation of the channel and review the management of the reservoir.

The 1996 project was funded by B.C. Hydro with DFO providing engineering and project supervision.

In 1995, 4600 cu.m. Of gravel was imported; in 1996, 3900 cu.m. was used.

The restored channel is 15 m to 20 m wide and 425 m long. Implementation of the project took place over 3 weeks during the instream construction window falling between July 1st and August 15th. Cofferdams were placed top and bottom of the channel coinciding with B.C. Hydro's ability to lower the river flow to 1200 cfs.

Three rock weirs were constructed in the channel with shot rock and round rock (the round rock covering the shot rock to provide as natural an appearance as possible). Spawning gravel, 2.5cm to 15cm (8" minus), was placed to a minimum depth of 0.6 m, in some locations over one metre was placed. The acceleration approach zone upstream of each notch in the weirs has a base of larger rock camouflaged with spawning gravel.

Additional features incorporated into the project include large boulders at the channel entrance to provide energy dispersion during flood events, and pools excavated into the banks that were provided with large root wads, logs and boulders to allow quiet backwater rearing habitat for juvenile fish. The project site falls within a provincial park, and extensive attention was paid to the rehabilitation of riparian areas affected by construction. Native plants were transplanted on the embankments in late September to take advantage of the fall rains.

- **CAMPBELL RIVER GRAVEL PLACEMENT PROJECT**

**1997, 1998**

| **Cost Summary:** | **1997** | **1998** |
|---|---|---|
| Tyee Club | $5,000 | |
| Steelhead Society | $5,000 | |
| Tide Guide Association | $5,000 | 2,500 |
| Habitat Conserv. Fund | $23,000 | 15,000 |

| | | |
|---|---|---|
| D.F.O. (constr. costs) | $87,000 | |
| D.F.O. (design/supervision) | $ 4,000 | $4,000 |
| B.C. Hydro | $25,000 | $25,000 |
| **Total:** | **$154,000** | **$46,500** |

**Introduction**:

The Department of Fisheries and Oceans and the local community initiated an experimental pilot project that attempts to restore salmon spawning habitat to the Campbell River. Gravel in the 2.5cm to 15cm (1 to 6 inch) range will increase the area available for naturally spawning salmon y. Gravel nourishment and placement was discussed at Vancouver Island Hydro/Fisheries Technical Committee following the results of the Lower Campbell River Aquatic Study (Burt & Burns Report 1995).

The gravel placement program was initiated through the Campbell River Gravel Committee with the co-operation DFO, MELP and BC Hydro, and community groups.
Site selection criteria included; preferred spawning conditions of chinook salmon, accessibility by helicopter longlining, hydraulic considerations, such as flow, depth, shear force at various flows, and the presence of naturally occurring boulders, large woody debris and backeddys that would slow the downstream migration of the gravel

**Project Description:**

This project was funded jointly by DFO, B.C. Hydro, MELP through the Habitat Conservation Fund, and community groups- the Tyee Club, Steelhead Society and Tideguide Association. DFO provided engineering, biological support and project administration and supervision. Dr. Bob Newberry, hydrologist, provided information and advice on the river dynamics, gravel stability and site suitability. Equipment and material requirements for the project included; a Bell 212 helicopter, supplied by Canadian Coast Guard; an excavator to load the buckets and trucks to supply and deliver washed spawning gravel to the staging site at the substation at John Hart Generating Station and the bridge site. A loader and tandem truck with a side cast conveyor was used at the bridge site to unload gravel off the bridge and an excavator placed the gravel.

A Coast Guard Bell 212 helicopter with 34m longline (110 foot) was used to deliver the gravel to the upper three sites. Two metal buckets were fabricated, each weighing 160 kg (350 lbs), able to carry 0.47$m^3$ (0.62 cubic yards) of spawning gravel. The bucket design allowed for self-dumping, no additional pilot operated controls were required. A cable bridle fastened at the bottom of the bucket with locking shackles and fit into brackets with grooves welded to each side at the top of the bucket. The weight of the bucket and gravel kept the cables in the grooves. An excavator at the staging site filled each bucket. When the full bucket was lowered to the river site the cables slackened and released from the grooves, the gravel was dumped, and as the empty bucket was lifted it turned upside down. The empty bucket returned to the staging area, was unfastened by the two-man crew and the second full bucket attached. An additional ground crew member at the staging site was in communication with the pilot. Two pilots were on site, each flying about 20 round trips per hour then refuelling. A tally of the number of trips to each site was kept to determine the volume of gravel placed.

Initial surveys of the sites to receive gravel were used to estimate the amount of gravel to be deposited and the average depth of the placed gravel. Each site was marked out with coloured buoys, visible to the helicopter pilots. Low summer rearing flows of 1200cfs (34cms) meant that the gravel could be placed to water level, an easy benchmark for the pilots to follow. During spawning flows, about 4300cfs (122cms) these sites will be covered by 1m of water, suitable depth for chinook spawning. Spawning gravel was placed to an average depth of 0.6 to 1.0m at the three sites.

Topographical surveys and records of gravel delivered to the sites indicate that Site 1 received 123$m^3$, with an average depth of 0.7m, for a spawning area of 175$m^2$, Site 2 received 136$m^3$ at 1.0m deep for 136$m^2$, and Site 3 received 95$m^3$ at 0.6m deep for 158$m^2$. Spawning platforms totalled 469$m^2$, creating habitat for up to 50 pairs of spawning chinook.

The three upper sites are located within Elk Falls Provincial Park and park officials were notified of the project and the activities involved. Parts of the river and a popular walking trail along the river had to be closed to recreational users.

In addition to the helicopter gravel placement a further 1400$m^2$ spawning area was created at the site of the new Campbell River highway bridge construction. With the co-operation of the construction company, a temporary bridge, in place to construct the concrete support pier, was used to deliver 715$m^3$ of gravel. Gravel was dumped off the bridge with a loader and a tandem with an attached side cast conveyor. After the temporary bridge was removed an excavator placed the gravel in the river over a specified area, to an average depth of 0.3 to 0.6m.

A program has been designed to monitor the stability and condition of the spawning gravel, and its usage by salmonids over the next few years.

During August 1998 spawning gravel was further supplemented at site 3 (Gravel placement 1997) and at three new smaller sites using Bobcats and a fabricated chute (1/4" steel plate) to deliver the spawning gravel to the river. A Bobcat (Case) delivered gravel to the river with the use of a 30ft chute down a steep bank. As the spawning gravel stands at an angle of 35 degrees the slope of the chute had to exceed this angle. A second Bobcat worked on top of the delivered gravel to spread it over the designated area. In addition tracked wheelbarrows deposited gravel in accessible areas off the Canyon View trail. Shovels and rakes were used to spread the gravel to create spawning pads along the river bank. The gravel will be monitored to determine movement over time and assess use by salmonids. This project will further increase the effective spawning area in the Campbell River, for chinook as well as coho, chum, pinks, steelhead and cutthroat trout.

- **RAVEN CHANNEL**

Raven Channel, constructed in August of 1998, is situated on the lower left bank of the Campbell River. The upstream end between the Highway and Tamarac bridges. The channel is 300m long and 4-6m wide excavated on a flood plain area of the Campbell and exiting into a natural slough. The lower river was historically an important chinook and chum natural spawning habitat which high river flows and reduced gravel recruitment had seriously depleted. Some spawning area has been incorporated, with an additional spawning area placed at the mainstem river entrance to the channel. The channel remains wetted at all target river flows, even low summer rearing flows (1200cfs, 35cms) providing additional year round rearing and spawning for all species. An important component of this fish habitat project is the creation of off-channel rearing habitat for juvenile salmonids, providing refuge from high flows, and riparian zones which contribute food to the system as well as shade and decaying plant material. Pools include alcoves with stumps, logs and large boulders to provide cover for juvenile and adult returning salmon. The area is tidally influenced with water levels and flow patterns changing with tide height, but remaining freshwater. Tidal influence increases the wetted area and adds more organics from channel banks to the system.

# Campbell River Estuary Habitat Restoration Projects

**Introduction:**

- The Campbell River estuary comprises an intertidal area of about 72.5 hectares. Since 1904 the estuary has been used for industrial purposes, degrading the habitat by altering the shorelines, dredging, storing log booms and bundles on intertidal habitat, scouring and shading of substrate preventing vegetative production, deposition of wood waste, and construction of marinas and seaplane facilities. These activities have resulted in significant losses of estuarine habitats, areas extremely important to the survival of juvenile salmonids. The estuary functions as a nursery for all species of salmon. The Campbell River chinook are especially reliant on the estuary as primary rearing habitat. Food production within the estuary is directly related to the detrital food chain and depends on vegetated intertidal areas to fuel the system. Contribution from freshwater, terrestrial, and marine drift brought in with the tides are also important to the productivity of the environment. In addition to the food production the estuary provides juveniles with critical physiological transition from fresh to saltwater with its tidally varied and gradient salinity habitats. Estuarine rearing capacity has been recognized as a limiting factor to improved salmon production (CRIFMS p11). The implementation of the Campbell River Estuary Management Plan provides a system of checks and balances that will protect and monitor future activities affecting the estuary.

**Intertidal Island Creation (1982)**

- In 1981 the proposed construction of a dryland sort and log pond by BCFP resulted in the rehabilitation of part of the estuary to compensate for the destruction of marsh habitat. Four intertidal islands were constructed in the old booming area of the estuary, using the dredge spoil from excavation of the log pond. The islands were planted with marsh grasses to increase the productivity of the area and alcoves were excavated in the margins of the islands to provide refuge for juvenile salmonids. Completed in 1982 the islands have been monitored to assess the success of the grass transplants, the contribution to food production, bird usage and the overall utilization of the estuarine habitat by juvenile salmonids.

**Intertidal Bench Creation (1997) MarineLink**

- An intertidal bench was constructed at the abandoned MarineLink landing barge ramp. An area approximately 100m by 10m (1000m2) provides increased intertidal vegetation production and juvenile rearing habitat.

**Intertidal Marsh Creation at Spit road to Discovery Harbour**

- A habitat mitigation/compensation project on the marsh of Nunns Creek resulting from the construction of Discovery Harbour Mall reclaimed 9000$m^2$ of sedge and rush habitat. Shallow channels were excavated and the slopes planted by hand with plugs of *carex* and *juncus* from donor stock salvaged from the construction site. Upland, riparian zones have also been included. The reclamation of 'old'Spit Road will add further habitat to the intertidal freshwater marsh area.

**River Breach and Intertidal Bench Creation (1996/1997)**

- Habitat improvements to increase the rearing capacity of the estuary were identified as priorities in order to support the proposed spawning targets for the Campbell. In accordance with Fisheries and Oceans requisite of "no net loss of productive capacity of habitat" four intertidal islands were constructed in 1981 in compensation for the loss of marsh and riparian habitat resulting from construction of the log sort pocket. The 5-7m deep dredged pond offered little of the productive margin habitat preferred by migrating and rearing juveniles and decay of accumulated wood waste had decreased the water quality, especially the dissolved oxygen levels. Breaching the training wall

separating the now abandoned log sort pocket from the mainstem river in August 1996 allowed for an improved water exchange as well as allowing juveniles access to the east side of the estuary. A *carex* bench 600m$^2$ was created from the spoil excavated and *carex* salvaged from the breach site. To further increase the productivity of the estuary an area of 6000m$^2$, on the western and northern shores of the log sort pond of upland gravel was excavated to intertidal beach in August of 1997. This increased the potential for intertidal vegetation, 1700m$^2$ of which is at an elevation suitable for *carex* and *juncus* establishment. Four channels were excavated through the benches to allow further exchange between the river and the log sort pond.

**Bank Stabilization Project (1998)**

- Another concern in the tidal freshwater area of the estuary was 275m of bank with active erosion on the lower right bank of the river at the oxbow. A cut bank topped by asphalt was eroding with the asphalt breaking off into the river. A hydrologist report indicated that the river width was acceptable for the mean annual discharge of the system and the bank should not be under excessive velocities. Initial excavation in August 97 was halted when the site was found to be contaminated from a 1947 oil spill. Timberwest, owner of the property, hired a consultant, Pottinger Gaherty Environmental Consultants Ltd to deal with the remediation of the contamination. Contaminated soil was removed to a remediation pit on another Timberwest property and replaced with clean fill. In January of 1998 the site had been cleaned up and the habitat restoration and bank stabilization project commenced. By pulling the bank back at 2:1 from the river bottom and armouring this slope with riprap a stable toe was established. The creation of a tidal freshwater bench at 3.8m (chart datum) from the riprap, 10-14m wide, allowed for an increase in width of the river at higher flows, decreasing the erosional forces on the bank and providing increased wetted area, 3400m$^2$, allowing for greater fish habitat. The upper 3:1 slope of the bench, which is partially wetted on high tides, was planted with riparian species (~1500 red osier dogwood, willow, vine maple, alder, and hardhack) to further improve the habitat. Large boulder clusters were also placed on the bench to add complexity, creating backeddys and cover. The bench will be further planted with native species found on the opposite bank, if necessary.

**East Bank Intertidal Benching (1998)**

- The clean fill excavated from the bank stabilization project was used to produce further intertidal sedge marsh habitat on the eastern side of the log sort pocket. Cutting into the existing bank created additional benching when the excess spoil material had been used. This resulted in 3500m$^2$ of intertidal habitat.

**Net production of Habitat 1996 to 1998 in the Campbell Estuary**

- August 1996 to January 1998 has produced 5700m$^2$ of intertidal sedge marsh bench, and 7800m$^2$ of intertidal beach.

## Present Habitat Restoration Projects 1999

- Reclamation of the Tyee Spit, returning the altered, armoured and bulkheaded shoreline to a natural slope with associated vegetation and habitats. **$30,000**
- Marsh grass planting on the intertidal benching produced in 1997/98. **$40,000**
- Additional channel creation and marsh planting in Nunns Creek. This project is in conjunction with the decommissioning of Spit Rd and habitat compensation agreement with the Discovery Harbour Mall. **$70,000**

## Future Projects in the Campbell River Estuary

- Establishing a trail following the right bank from the foot of Maple Street to the end of the upland area downstream. This groomed trail will include interpretative signs; bridges to allow access over breach channels, and wildlife viewing areas. The trail will be built on municipal land. Fill removed from the Raven Park channel has already been moved on site and a preliminary base established.
- Habitat restoration of the west side of the estuary, including Baikie Slough, an area seriously degraded by log handling activities. Improvements include requiring more fish friendly industrial activities, improved fresh water flushing, establishing marsh grasses, cleaning up of deposited wood waste
- Groundwork is underway to attempt to acquire a parcel of 50 acres on the west side of the estuary.
- Continued removal of bulkheads on the shoreline of Tyee Spit, as possible to return to natural slope and/or marsh benches.

Appendix B. List of Coded-wire tag codes used to represent production of Quinsam Hatchery fall chinook in cohort analyses, by brood year (@ sign indicates the brood year).

| @74 | @85 | @89 | @93 |
|---|---|---|---|
| 020403 | 023522 | 026062 | 180629 |
| @75 | 023523 | 026063 | 180630 |
| 020108 | 023524 | 026101 | 180631 |
| @76 | 023525 | 026102 | 181357 |
| 021916 | 023554 | 020361 | 181358 |
| @77 | 023555 | 020360 | 181359 |
| 021736 | 023556 | 020359 | 181360 |
| 021737 | 023557 | 020358 | 181361 |
| 021738 | 023558 | 020357 | 181362 |
| @78 | @86 | @90 | @94 |
| 021759 | 024152 | 020956 | 181644 |
| @79 | 024153 | 020957 | 181645 |
| 021757 | 024154 | 020958 | 181646 |
| 021758 | 024155 | 020959 | 181647 |
| @80 | 024156 | 021448 | 181648 |
| 021657 | 024157 | 021449 | 181649 |
| 021943 | 024158 | 021450 | 181650 |
| 021950 | 024159 | 021451 | 181651 |
| @81 | 024160 | 026019 | 181652 |
| 022303 | @87 | @91 | @95 |
| 022304 | 024419 | 180422 | 181658 |
| @82 | 024420 | 180421 | 181659 |
| 022518 | 024421 | 180420 | 181660 |
| 022519 | 024956 | 180419 | 181661 |
| @83 | 025358 | 180418 | 182016 |
| 022631 | 025359 | 180417 | 182017 |
| 022632 | 025360 | 180416 | 182018 |
| @84 | 025361 | 180415 | 182020 |
| 023322 | 025362 | 021331 | 182021 |
| 023323 | @88 | @92 | @96 |
| 023324 | 025814 | 181150 | 181830 |
| 023325 | 025815 | 181151 | 182512 |
| 023326 | 025816 | 181152 | 182513 |
| 023327 | 025817 | 181153 | 182514 |
| 023328 | 025818 | 181154 | 182515 |
| 023329 | 025819 | 181155 | 182516 |
| 023330 | 025820 | 181156 | 182517 |
| | 025821 | 181157 | 182518 |
| | 025822 | 181158 | @97 |
| | | | 183035 |
| | | | 183036 |
| | | | 183037 |
| | | | 183038 |
| | | | 183039 |
| | | | 183040 |
| | | | 183041 |